H. M. S. VICTORIA.

THE new first-class ship of war Victoria, built at Elswick, on the Tyne, by Sir W. G. Armstrong, Mitchell & Co., for her Majesty's government, went down the river recently and proceeded to Chatham Dockyard. She was towed by four powerful tugs, two in front of her and one at each side. Being the largest vessel ever launched on the Tyne, she was an object of great interest to the townfolk, and her progress was watched by tens of thousands of spectators on the river banks, wharves, and quays, and on the bridges. Several of the Tyne commissioners and of the corporation of Newcastle were on the wooden structure below the Swing Bridge, carefully observing the passage of that point by the huge ship, which drew 24 ft. of water forward and 25 ft. aft; but the river had been dredged for the occasion, and the depth was sufficient. There was a momentary anxiety about the width of the space

examples than the Victory and the Victoria, so alike in name and yet so different in all things else. The Victory, I need hardly say, was the famous line-of-battle ship in which Nelson fought and died. She was one of the largest ships of her day, but her displacement or total weight with everything on board was only 3,500 tons, while the displacement of the Victoria will be 10,500 tons. The Victory, in accordance with the usage of the time, was built of oak. The Victoria, in accordance with the present practice, is built of iron. The Victory was propelled by wind, over which man has no control. The Victoria will be propelled by steam, over which man has perfect mastery. The Victory had the character of being an extraordinary quick sailer, and when the wind in its vagaries happened to be exceptionally propitious, she could attain a speed of nearly 13 knots an hour. The Victoria, propelled by engines of more than 12,000 h. p., may be expected to achieve about 17 knots an hour, and will

four above water and four below water. In the fighting days of the Victory, ramming was little practiced and torpedoes were wholly unknown. Therefore, in these respects no comparison can be drawn. But there is another point of view in which the Victoria compares in a highly favorable degree with the Victory, and that is in the smallness of the number of officers and men required to handle and fight the ship. The complement of officers and men on board the Victory was 850, while on board the Victoria it will only be 550, of whom 110 will be engineers and stokers, leaving only 440 officers and men in a combatant capacity. Thus, although the Victoria is three times as big as the Victory, and prodigiously superior in offensive power, there will only be half the number of men exposed to death and wounds in the working of her armament. This result is chiefly due to mechanical appliances which in recent years have been introduced for working the guns. At the commencement of my career as an artillerist it

THE NEW BRITISH WAR SHIP VICTORIA.

between the wooden pier here and the stone pier of the High Level Bridge, alongside of which a raft had been moored, while another raft was attached to the other side of the ship, to prevent her crushing directly against either one or the other. The ship actually came so close to the wooden pier that the intervening timbers were ground and splintered, and the chains of the raft were snapped, by the enormous force of her momentum ; but no real damage was done. As she got past the bridges a hearty cheer was raised by the people on them and on the shore, to which the ship responded with a mighty screech of her fog horn. Our illustration is from a photograph given in the London *Graphic.*

The Victoria is one of the largest ironclads in the British navy. Her dimensions are : Length, 340 ft.; breadth, 70 ft.; mean draught, 25 ft. 9 in.; displacements in tons, 10,500 ; h. p., 12,000. She is protected by armor 18 in. thick, and is armed with two 110-ton guns, one 30-ton gun, 12 five-ton guns, 12 six-inch quick-firing guns, nine three-pounder quick-firing guns, besides machine guns for smaller ammunition. She also has a powerful ram and eight torpedo dischargers. The Victoria being the heaviest vessel ever launched off the Tyne, the proceedings, April 9, 1887, were witnessed by about 150,000 persons, who took up positions on both sides of the river, and even on the Redheugh Bridge, half a mile away, for the purpose of witnessing the monster craft as she took to the water.

On the occasion of the launch, Sir William Armstrong said : " For the purpose of comparison between ships of the old sort and the new, I can take no more fitting

be independent of the wind. In regard to armament, the comparison in favor of the Victoria is astounding, and ought to open the eyes of those who are in the habit of disparaging the progress of artillery in this country. The armament of the Victory as she fought at Trafalgar consisted of 30 32-pounders, 30 24-pounders, 40 12-pounders, and two 68-pounder carronades, making in all 102 guns. The heaviest of these guns was under three tons, while the heaviest on board the Victoria will be 110 tons. The largest charge of powder used on the Victory was 8 lb., while the largest charge to be used on the Victoria will be 900 lb. The heaviest shot used in the Victory was 68 lb., while in the Victoria it will be 1,800 lb. The weight of metal discharged from the broadside of the Victory was 1,150 lb., against 4,750 lb. from that of the Victoria. But the power of the broadside discharge of each ship is better indicated by the quantity of powder expended than by the weight of metal discharged ; and while the broadside fire from the Victory consumed only 325 lb., that from the Victoria will consume 3,000 lb. In point of range, accuracy, penetrating power, and shell power the difference is so great in favor of the Victoria that a comparison would be ridiculous. I have yet to give you the particulars of the Victoria's armament. It will consist of two 110-ton guns, mounted on a revolving turret and firing ahead or on either side ; 12 five-ton guns, 12 six-pounder quick-firing guns, and nine three-pounder quick-firing guns, and a considerable number of machine guns for smaller ammunition. Besides her artillery armament the Victoria has a powerful ram, and she carries eight torpedo dischargers—

was regarded as an axiom that no gun exceeding 5 tons weight could be worked on a moving platform such as the deck of a ship. A gun of 5 tons 12 cwt., firing a charge of 20 lb. of powder and a shot of 68 lb., has been tried on shipboard and found unmanageable, and it had to be replaced by a gun of 4 tons 15 cwt., firing only 16 lb. with the same weight of shot. At the present day we have to deal with guns of 110 tons, which have to be charged with powder and shot weighing together 2,700 lb. It is manifest that the loading and manipulation of such a gun could not possibly be effected by the manual labor of any number of men that could be crowded around the gun, but it has been effected by the employment of a very few men acting through the agency of hydraulic machinery invented and reduced to practice by the former Elswick company, and largely covered by patents now vested in the present company. Then, again, to go from the largest to the smallest artillery gun to be used in the Victoria, which is the 3-pounder Hotchkiss quick-firing gun, we have another example of what mechanicians have done for artillery. It is a gun of great range and penetrative power, which by means of mechanical arrangements can be fired with deliberate aim twenty times a minute by the employment of only three men. Or, if we take the quick-firing gun which has recently been designed and perfected at Elswick, and which fires any desired weight of projectile between 30 lb. and 40 lb., and compare it with the old 32-pounder such as the Victory carried, and which required eight men to work it at the rate of one round a minute, we have in the new weapon a gun of enormously greater power, which

can fire ten rounds a minute with only four men to serve it, so that this gun with four men to serve it will fire as many rounds per minute as could formerly be fired by eighty men with ten guns.

"But while admitting, as all must do, the vast superiority of modern war ships over those which preceded them, you will probably say, "Look at their enormously greater cost and the burdens they impose upon the taxpayers." Now, I think there is a great deal of fallacy about the impoverishing effect upon the nation of this increase of cost; every penny spent upon ships of war is spent in the country, and every article used in their construction is derived from the natural resources of the country. The nation, taken as a whole, pays for its ships out of one pocket and receives the money into the other, and I do not see that it is much the worse for the operation. Much is said about the difference between productive and non-productive expenditure, but I fail to see how expenditure on war ships can be called unproductive when we gain by it protection from aggression on our coasts, our colonies, and our commerce."

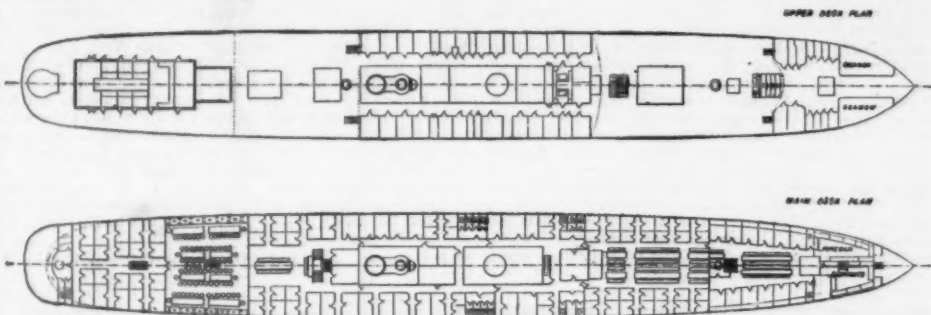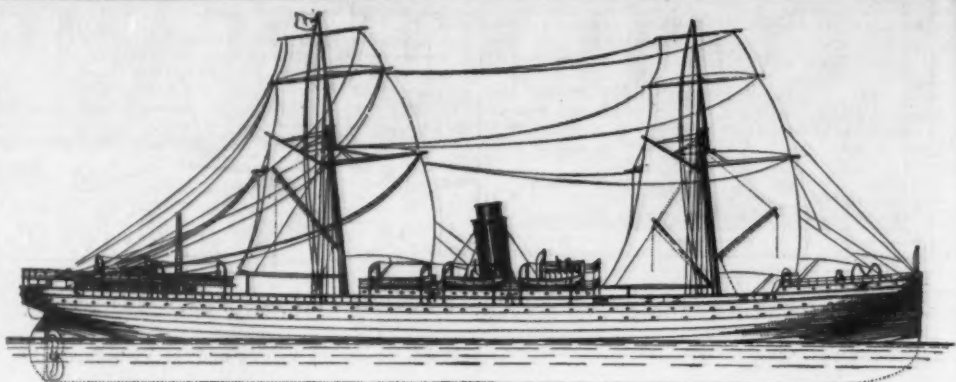### TRIAL OF THE VICTORIA FOR SPEED AND POWER.

The forced draught steam trial of H. M. line-of-battle ship Victoria took place on June 14 off the Maplin Sands, under very favorable conditions, the sea being quite smooth. Some little delay was caused in getting the anchor on deck, which necessitated a partial banking of the fires, and somewhat affected the immediate development of the full horse power; but by the time the ship had reached deep water the engines began to make 105 revolutions per minute, and maintained the rate during the four hours' trial. The ship was remarkably steady, and notwithstanding the tremendous power of the engines, scarcely any vibration whatever was felt in any part of the ship. Mr. Humphrey, the contractor, was on board, and must have been highly gratified at the result, for his engines developed 2,344 horse power over the contract requirements, and thus secured the contractors a premium of £28,000. We believe the agreement with the Admiralty was that if the engines exceeded 12,000 horse-power the contractors were to receive £6 13s. 4d. for every horse power in excess of 10,000. The original contract was £98,000, so that with the added premium Messrs. Humphrey will receive no less than £126,000. The speed of the ship, 17·4 knots, or 20 miles an hour, was considered highly satisfactory. The engines worked without the slightest hitch from beginning to end. We are curious to know, says the *Broad Arrow*, why so large a premium was paid, and upon what base of calculation the sum of £6 13s. 4d. comes in.

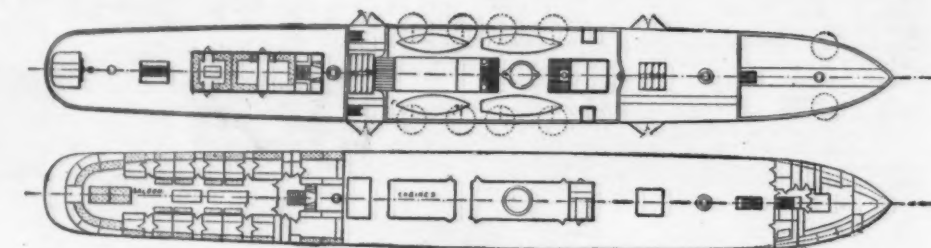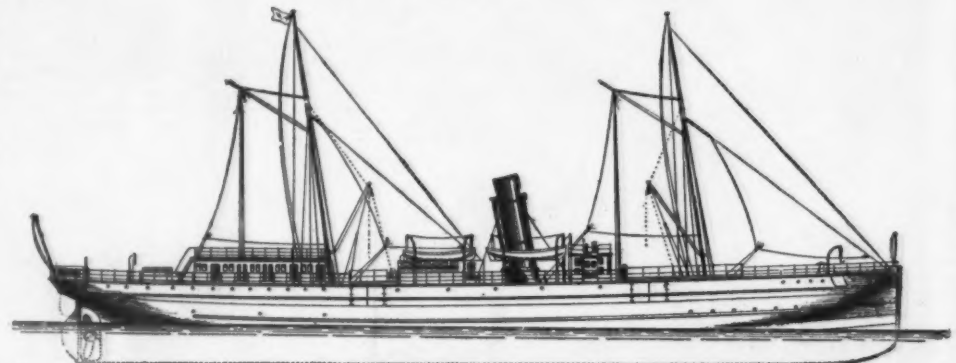### NAVAL ARCHITECTURE IN THE GLASGOW EXHIBITION.

In the main avenue of the exhibition are many superior vessels, some of which we herewith illustrate from the *Engineer*.

The steamer Roslin Castle was built about five years ago by Messrs. Barclay, Curle & Co., for the well-known Castle line of Donald Currie & Co., which trades to the Cape and other parts of South Africa. Her dimensions are 380 ft. by 48·3 ft. beam and 31·45 ft. depth of hold, the gross tonnage being 4,281 tons and net tonnage 2,746 tons. At present she is fitted with compound direct action surface-condensing engines having cylinders 50 in. and 90 in. in diameter and a 60 in. stroke, her consumption of coals being 1·9 lb. per indicated horse power per hour, and speed 14¾ knots. It is understood, however, that Messrs. Currie intend replacing these with triple expansion engines, in order to still further economize in her working and keep pace with modern improvements. The full model of the Roslin Castle is handsomely finished, and faithfully shows the form and details of this excellent vessel, so well known and popular on the Cape route. Many important features in the design cannot, unfortunately, be indicated in a model; and not the least interesting of these is the extensive bulkhead subdivision and the powerful system of pumping with which she is provided. Such provision for the safety of passengers deserves the highest commendation. In addition to the most powerful description of Downton's manual deck pumps, the Roslin Castle has 15 in. suction pipes in each main compartment, these being in connection with the main steam pumps, and with other steam pumps of great power made by Messrs. Gwynne, of London. There can be no doubt that this is the class of vessel which could be best utilized as an armed cruiser for the protection of our commerce in time of war, as in addition to the before mentioned provisions for safety in the form of bulkhead subdivision and powerful pumping capabilities, her great beam and strength would enable her to carry and fight a comparatively heavy armament on the upper hurricane and forecastle decks, besides discharging broadside and fore-and-aft torpedoes. Her spacious decks would also permit of her carrying several torpedo boats, while protection for her machinery, boilers, and the necessary magazines and shell rooms can be well afforded by longitudinal and transverse coal bunkers.
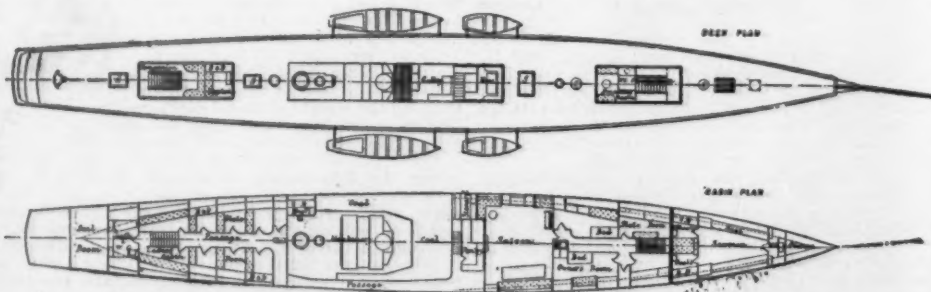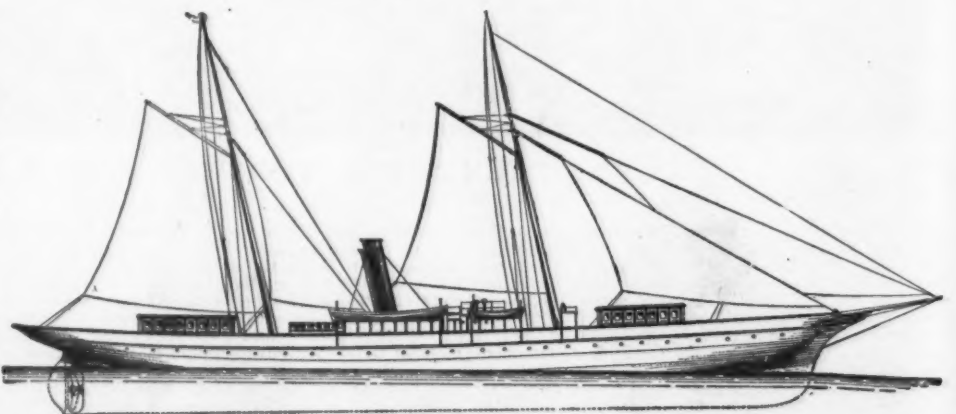
The next model in Messrs. Barclay, Curle & Co.'s collection to which attention should be drawn is that of the well-known screw steamers Alligator, Dromedary, and Gorilla, owned by Messrs. G. & J. Burns, and running regularly in the passenger trade between Glasgow and Belfast. These vessels are deservedly popular with passengers, and seem to fulfill in the highest degree the requirement for the service in which they are employed. Their registered dimensions are 250 ft. by 30 ft. beam and 14 ft. 9 in. depth of hold, being fitted with a poop, hurricane deck amidships, and a top-gallant forecastle, as will be seen by our illustration. The vessels of the Alligator class were specially designed to replace the admirable service of paddle steamers which the Messrs. Burns ran between the same ports for many years with great success and remarkable immunity from accident. The model is well put out of hand, and conveys an accurate idea of the well proportioned and skillfully designed form which is a marked characteristic of the Belfast liners. Their engines are compound surface condensing, with 38½ in. and 69 in. cylinders, and 48 in. stroke, and under favorable conditions they attain a mean speed on their route of 15½ knots an hour. Being supplied with extensive passenger accommodation, the owners have very properly taken such precautions for safety as are to be found

SS. ROSLIN CASTLE.

SS. ALLIGATOR.

STEAM YACHT CAPERCAILZIE.

in additional watertight bulkheads, and the comfort of those who travel by their steamers has been carefully considered in every department. The Hare is a smaller vessel than those of the Alligator class, being 216 ft. by 29 ft. 6 in. and 14 ft. 9 in. depth of hold, and she plies on the Royal Mail service in the shorter run between Ardrossan and Belfast. She has a speed of fourteen knots, which enables her to run with regularity on what is known as the "daylight route" between the West of Scotland and North of Ireland. It is worthy of remark that the Hare is built substantially, of Siemens-Martin steel, and, being almost new, is fitted with triple expansion engines having cylinders 24 in., 38 in., and 58 in. diameter, with a 42 in. stroke, her fuel consumption being stated as 1½ lb. of Scotch coal per indicated horse power per hour. Our third illustration of Messrs. Barclay, Curle & Co.'s exhibits shows the full-rigged, handsomely finished model of the iron screw steam yacht Capercailzie, built by them for Mr. John Burns, of Castle Wemyss, Renfrewshire, to replace the Jacamar—by the same builders—which was recently purchased by the Admiralty and named Imogene, for the service of the British ambassador at Constantinople. The registered dimensions of the Capercailzie are 193 ft. by 24 ft. by 13 ft. depth of hold, and she is fitted with compound engines having 23 in. and 42 in. cylinders, with a 30 in. stroke. Her speed is 13½ knots, with about 100 tons of coal on board and fully equipped for sea, on a consumption, it is said, of 1·89 lb. per indicated horse power per hour. The yacht is of graceful form and is elegantly fitted.

FORGED CAST STEEL PROJECTILES.

It is generally well known that for some time our Woolwich authorities have very favorably received foreign steel projectiles for experimental and for more extended use. Considerable orders have been sent to the Continent for projectiles assumed to be of remarkable quality, and much to the annoyance of some of our Sheffield manufacturers. Our gunnery authorities have, however, now a very good knowledge of what the Continent can produce, and have now turned their attention again to some home manufactures.

In March last the Admiralty commenced a series of trials on board the Nettle with English steel and compound armor of different kinds, with a view to clearing away uncertainty as to the relative values of different forms of armor and backing. Other trials have been made at Shoeburyness, and some of Hadfield's forged steel projectiles used. Of three of these we give engravings from photographs, showing their condition after penetrating the armor as follows : The projectile marked No. 1 is a 6 in. projectile—Hadfield's forged cast steel—and has penetrated a 9 in. compound steel plate made in Sheffield, and 3 ft. into timber placed behind ; striking velocity, 1,876 ft.; energy, 2,462 foot tons. The face of this plate was specially hard, containing 1½ per cent. carbon. This was the first English projectile that successfully pierced the compound armor plates ; and although it broke into three pieces, as shown, after passing through the plate, this performance was then not reached, or even approached, by any other. The projectile No. 2 is a 9·2 in. projectile—Hadfield's unhammered cast steel—and has penetrated a 16½ in. Cammell wrought iron armor plate placed behind, making a total penetration of 24¾ in.; striking velocity, 1,780 ft. per second ; energy, 9,200 foot tons ; charge, cocoa powder, 160 lb. The No. 3 projectile is a 6 in. projectile—Hadfield's unhammered cast steel—and has passed through an 8 in. Brown wrought iron armor plate. It is practically uninjured, having only set up 1/16 in., and could be fired again from the same gun ; striking energy, 2,500 foot tons. Another shell of Hadfield's steel, which we do not engrave, for it remained apparently unaffected by the work it did, pierced the same very hard armor. This rather takes away the feeling of satisfaction with the armor which had been expressed, as although the Holtzer projectiles

HYDROSTATIC DISAPPEARING TURRET.

Our readers doubtless remember that we have already several times endeavored to impress upon their minds the importance of armor-clad turrets in the operations of the defense of fortified towns. Now such importance, duly stated, has assumed considerable proportions since the first ballistic torpedoes were put in service, and since it has been found that there

HYDROSTATIC DISAPPEARING TURRET.

are no longer any invulnerable earthworks or masonry. There is no longer, it is said, anything but the turret that can resist the action of hollow projectiles fired under a breaking charge, and this metallic structure is an indispensable element of every defensive organization. That is true, at least provisionally ; we mean until the relative invulnerability of the armor-clad turret becomes a fact definitely acquired by experience. The turret of the primitive type consists, we have said, of a large metallic cylinder resting upon solid masonry substructures through the intermedium of a ring of rollers analogous to that of a railroad turn table. Through the play of this arrangement, the cylinder is

chamber permits of revolving the previously eased-up apparatus. The play of this revolving turret is easily understood. Standing in a neighboring observatory, the artilleryman looks over the ground of the attack. He can, at will, slacken, accelerate, or arrest the rotary motion, or reverse the direction of it. At the proper moment, he fires, and, when this is done, the turret, which has quickly revolved, presents to the enemy the entire portion of its carapax, that is to say, that portion of the cylinder that contains no embrasures, so that the latter escape all danger from shots in reply.

Very well. The trouble is that, however well established it is supposed to be, the projecting portion of the metallic cylinder is far from being as invulnerable as might be thought, for melinite shells soon perforate it. This being the case, military engineers have believed it their duty to discard the arrangement involving the permanent projection of the upper part of the turret and have recourse to the adoption of the principle of the eclipse. In this system, the cylinder is capable of not only revolving around its axis, but also of moving upward and downward. These latter motions may be so effected at the will of the operator that the emersions shall be but momentary, and that the duration of each shall not exceed the limit of the time necessary for firing. Scarcely have the guns been fired when the cylinder descends in its entirety into the ground in which its envelope is buried, and thus escapes the projectiles of the adversary.

Several types of turrets established upon the principle of the eclipse are already distinguished. At present, we shall describe only the apparatus of this nature proposed by Colonel Souriau, and which has just been elaborated in all its details by Messrs. Schneider & Co., of the Creusot works.

The author had observed that in order to put so large a mass as that of a turret in motion it is necessary to have recourse to the use of powerful mechanical motors (hydraulic, steam, or electric) ; that the weight to be moved must necessarily be relieved by means of counterpoises or hydraulic apparatus ; that, in any case, the motors employed (steam or hydraulic) can be maneuvered only by experienced mechanicians ; that the recruiting of special men in time of war may present certain difficulties ; that, as regards the mechanism of the turret, all the parts must be kept constantly in order ; that it is indispensable to make frequent verifications of such perfect state of order ; that consequently we must admit the necessity of a continuous series of making ready for action ; and, finally, that each of these periodical experiments costs considerable money. That being the case, Colonel Souriau decided to confine himself to the use of extremely simple mechanisms that could be actuated by manual power ; and, under such conditions, the following is the way that this officer has solved the problem.

The construction of the apparatus that he recommends is based upon the principle of the indifferent equilibrium of bodies immersed in a liquid. The accompanying figure represents a hydrostatic turret, T T, resting through the intermedium of a cylinder, C, upon a plunger, P, which consists of a hollow iron plate cylinder immersed in a well filled with water. The cylinder, C, which emerges, is, moreover, of such dimensions that it balances the weight of the entire part out of water. Hence it follows that but a slight stress suffices to produce a vertical motion of the system, and that such stress may be exerted by a few arms acting upon the winches of a simple mechanism. The improvement in the model elaborated by the Creusot engineers requires but four men, and this reduced force effects the putting in battery in the space of fifteen seconds, and afterward the disappearance of the turret
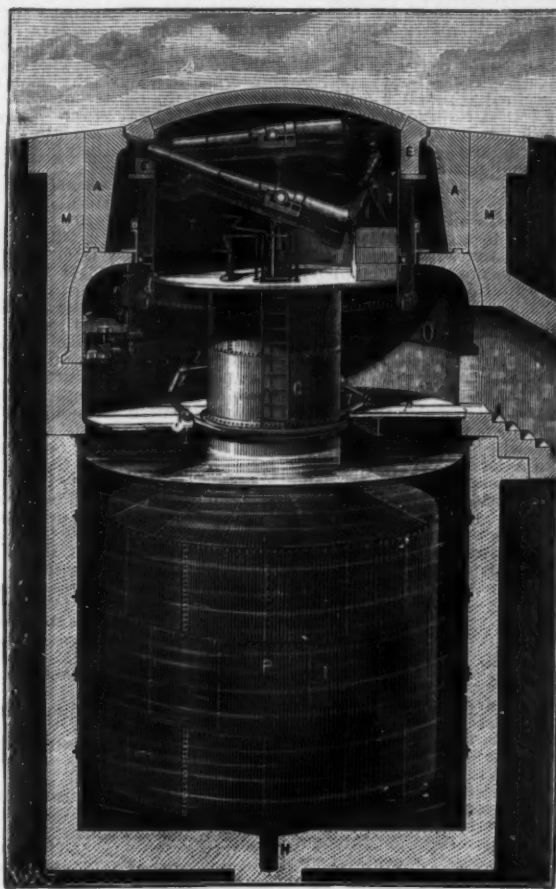

HADFIELD'S STEEL PROJECTILES AFTER PIERCING STEEL ARMOR.

failed, the Hadfield steel penetrated without the projectile breaking in the least. This is a most remarkable result, and it is very satisfactory to find that after all the experimenting with shot and shell made by various foreign manufacturers, projectiles of English manufacture alone have penetrated the most impenetrable armor yet made.—*The Engineer*.

capable of revolving around its axis, and its motion may be regulated at will. It is covered with a flattish metallic cap, and projects but slightly above the mass of earth and masonry that protects it. This upper portion of the cylinder contains embrasures to give passage to the mouths of the guns in battery within. A very simple mechanism located in the maneuvering

in the same space of time, say altogether half a minute for the ascent and descent.

A few details of organization will not be here out of place.

The whole emergent part, E E, is armor-clad with Schneider plates. The same is the case with the top, which is divided into segments. The gun chamber, or turret properly so called, is protected by a cuirass, A A, serving as a lining to the masonry, M M. The turret, T, the emergent cylinder, C, and the plunger, P, form, as a whole, a rigid system, well guided below by the pivot, H, and above by a steel rim adjoining the cuirass, A A. The parts that effect the rotary and upward and downward motions are accessible from the floor, p, which is stationary, and are maneuvered by one and the same set of men.

The rotary motion is obtained through the play of a double-speed windlass, t t, fixed to the lower part of the cuirass, A A, and forming part of a vertical pinion, r. Through this latter the windlass actuates a toothed wheel, d, contiguous to the shell of the turret, and the teeth of which remain engaged during the vertical motion.

For lowering the turret, there are used two slides jointed to levers, l l l, situated in a diametrical plane, and which move freely in a channel belonging to the cylinder, C. This mechanism is not shown completely in the figure, but the representation of the levers renders the operation of it sufficiently intelligible. Let us observe that it is so combined that the ascensional and descensional velocity keeps increasing from the starting point to the center of the travel, and decreases therefrom up to the point of arrival.

The turret cannot be deprived of its functions through the freezing of the water in which the plunger is immersed, for, aside from the fact that ice is scarcely to be feared at the depth at which the well is situated, it is always easy to make a mixture whose freezing point is below the lowest temperature that can occur in the climate of the region considered.

As for the armament, that consists of two 6 inch guns mounted on carriages which are provided with a hydraulic brake and which return automatically into battery. Each gun and its carriage is balanced by a plunger arranged like that of the turret. It takes but one man to do the maneuvering.—La Nature.

THE CORINTH (GREECE) SHIP CANAL.*

ONE of the most interesting as well as difficult engineering undertakings of our times is that of cutting a ship canal through the Isthmus of Corinth, and thus opening a new era in the trade relations of the whole Levant. This enterprise takes a peculiar interest to itself from the fact that the idea is such an old one, and that it has been left to our day to carry out a project which interested the Greek republics and which troubled the brain of a Roman emperor. The Isthmus of Corinth, which is about three miles wide at its narrowest place, connecting from time immemorial two busy seas, has always provoked the attention of shrewd minded men. The old Greeks, with their small flat-bottomed boats, quickly conceived the idea of a portage from sea to sea, and they facilitated this by constructing a rude sort of track, along which they dragged their boats on heavy trucks. The Romans, with their larger boats, saw the inconvenience and the waste of labor involved in all this, and thought of a cutting through the isthmus. We know now that with their implements it would have been the most herculean labor of antiquity had they carried out the design. Even in our day of gunpowder and dynamite the task has proved a most serious one.

While the canal of the Isthmus of Corinth will be of the utmost benefit to Greece, and while all the country is most interested in the undertaking, especially King George, the whole affair is in the hands of a French company. De Lesseps is getting to be a name to conjure by. The French company that has undertaken to pierce the Isthmus of Corinth was organized in 1881, under the honorary presidency of M. De Lesseps, and with General Turr as president and resident manager of the work. The technical name of the company is "Societe Internationale du Canal Maritime de Corinthe." The Greek government gave sanction to the undertaking and conceded the land for the canal as well as all the uncultivated land on either side of the survey, with the single condition that the work should be carried through to its completion by the company and that the Greek government should never be called upon for a subsidy. The actual work of digging began with appropriate ceremonies in the month of May, 1882. The capital of the company is 30,000,000 francs. The president, General Turr, is a man of great energy. He is a Pole by birth and fought under Garibaldi.

When the work was begun it was not looked upon as a very serious matter, but after several years of digging they came upon the solid rock that connects the Peloponnesus with the mainland. This proved to be a very hard quality of schist or granite, and very soon the contractors, who had not reckoned on this, were obliged to throw up their contracts and retire. This occasioned some delay, but those who had the matter in hand, nothing daunted, made a new estimate and secured new contractors, and in February last the work began again with renewed vigor. They are now (May 1, 1888) making great progress, when we take into consideration the difficulties found in the materials they are at work upon. They are extracting 7,500 cubic meters of rock each day. They employ a corps 2,800 men and fifteen engines, each drawing from sixty to seventy trucks. They are at work from one end to the other of the cutting, which stretches exactly 6,300 meters from sea to sea. The width is forty meters, and they intend to go down eight meters below sea level, giving the canal the same depth of water as is found in the Suez Canal. But the difficulties of cutting this canal are much greater than those that were found in constructing the Suez Canal. In that case it was a matter of digging out the sand of the desert; here it is a question of blasting. All night long explosions can be heard, and the day is spent in removing the debris. Gunpowder is found to be the best for blasting purposes and dynamite for shattering the rocks. The highest point of the cutting at La Calotte is ninety-seven meters above water level. At this point

* For full description and illustrations of the work of cutting the Corinth Canal see SCIENTIFIC AMERICAN SUPPLEMENT, Nos. 455 and 467.

the engineers have found their hardest nut to crack. On the average they have got down to a point fourteen meters above sea level, and hence the task before them is to go down through solid granite twenty-two meters more for a length of 6,300 meters. It will take three years at a most moderate estimate to accomplish this.

One of the satisfactory things about this work is that there is comparatively no sickness among the workmen, and the terrible experiences of the Suez undertaking and the even more awful ones at Panama are not repeated. Of course there are many accidents, as there are in any large quarry, and many cases of amputation. But the company has done everything it can to care for the sufferers. There is a regularly established hospital and a good physician resident. The 2,800 men are made up mostly of Montenegrins, Italians, and residents of Asia Minor. There are very few Greeks employed. As Mr. Rosenbush said, the Greeks are too lazy to work, and their highest ambition is to lounge around with cigarette in mouth and let others do the hard work. This seems to be a rather extreme statement, and your correspondent has seen many indications of industry during his investigations in Greece, but it is certainly a telling argument against Greek labor when such a large company has to go so far to get good workmen. It is true the Greek prefers to live by his wits rather than by manual labor, and he has no conception of the dignity of such labor.

At the western end of the canal, on the Gulf of Corinth, about two miles north of New Corinth, a town of about 3,500 inhabitants, are situated all the large depots and offices of the canal company. Here a new town is growing up called Isthmia, and in future will probably stretch all along the shore of the isthmus to New Corinth. The depth of water a short distance from the shore is thirty fathoms, and there are no drifting sands to obstruct the canal or the docks. There will be no such difficulty here as is found at Suez. The sides of the canal will be solid granite, and there will be no washing away or necessity of dredging. The largest docks will be at the eastern end. The tariff of the canal will be put down to a low figure, so as to catch all the coasting trade, and it is fully expected that, in spite of the great expense of the work, it will pay well in the end. Certainly the world will have a new debt to French enterprise, and especially to the genius of M. De Lesseps, without whose influence this difficult piece of engineering would not have been undertaken, certainly not without the precedence of the Suez Canal.

The immediate local influence has been that land in every direction about the canal has been increasing rapidly in value, especially in the town of New Corinth. This growing village is laid out with all the regularity of a Western city, with broad streets and a large park in the center. This place certainly has a great future before it. In ancient days, especially in Roman times, Corinth was the greatest city in Greece, and its commerce did not flag much behind that of Alexandria and Antioch. Its future promises to far outrival its past. The canal company is so desirous of getting rid of the waste granite on hand that the finest building material is at the disposal of any one who will take the trouble to cart it away. Hence, building is going on in every direction, and on every vacant plot of ground about Corinth one sees large piles of stone awaiting the mason's trowel. The safe thing about it is that there seems to be no danger of overdoing the matter. The demand will be greater than the supply for years to come.

The canal is already getting to be a great railroad center. Three lines concentrate at New Corinth now, and the railway undertakings in Greece are but just begun. One railway comes in from the northeast, and before many years will be connected with the through lines from northern Greece and central Europe. Salonica is the only rival of Corinth in that direction. Another line comes in from the west, running along the northern coast of Peloponnesus from Patras, and which will, before many years, be extended all along down the western coast of the peninsula. A third lines comes in from the south, from Nauplia, the first capital of modern Greece. This line will drain the eastern and central portions of the peninsula. These railroads have all been completed within the last few years. They were built largely with Greek capital, subsidized by the government. The engineering work was in the hands of German and Swiss contractors, and has been done in a most substantial fashion. The management is Greek, and compares very favorably with that of any country in Southern Europe. Corinth has suffered much from its bad reputation for unhealthfulness. The guide books have actually slandered it. At one time Corinth was a prominent candidate for the seat of the Greek government, but had to yield to Athens, the old historic and sentimental center. It was claimed at that time that Corinth was malarial. This charge was partially true of Old Corinth, situated four miles southwest of New Corinth, near the great plain stretching away to the southwest. But New Corinth has never had a local fever, and the bad reputation it has acquired is utterly libelous. As to Old Corinth, the great increase of cultivation, the opening of new districts, has almost entirely banished the malarial tendencies. At this season, beautiful vineyards stretch in every direction for miles and miles. The small sweet grape cultivated in these vineyards is dried in the sun and exported to all parts of the world in immense quantities as the "currant" of commerce, which word, it will be remembered, is simply a corruption of "Corinth." The busy season is in August, when the grape ripens. The value of the currants exported annually is about $10,000,000. The unique thing about this article of commerce is that it has been successfully cultivated in large quantities only in this locality, and the most of the so-called currants from Marseilles and other districts really come from Corinth. Besides this article, Corinth will be a great center for the export of olives and olive oil, and for cheese, which is used very largely in the manufacture of macaroni.

But the local trade will be infinitesimal as compared with the great through traffic which will be attracted by the canal. All of the growing trade of the northeastern part of the Levant will come this way. The opening of the canal will save eighteen hours of general discomfort to passenger boats from all the Italian ports en route for Constantinople and Smyrna. All the commerce between the Black Sea and the
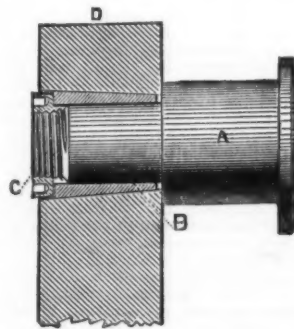
western Mediterranean will flow this way. The Greek kingdom will reap the greatest benefits from all this. The Greek race has always been a race of sailors and colonists, and the young kingdom has already made a strong push ahead in this its traditional line. A large part of the commerce of the Ægean and Black Seas is already in its hands. New steamship companies have been established and are plying in all directions. The Greek steamers that run from Patras to Corfu and Brindisi are clean and fast boats. Thus the commercial and traveling public will watch with the greatest interest the completion of this new artery of the world's life. Three years and possibly four must intervene before the throb of a new vigor will animate this ancient isthmus and more than restore to it its former prestige. In the meantime the Greek kingdom will have opened out more fully and will have learned how to profit by this windfall; for this little nation could never have undertaken such an engineering work and carried it through to success by its own power. In taking up this enterprise and carrying it to a successful issue, the West is but paying a small portion of that immense debt it owes to the genius of the forefathers of the modern Greeks.—Corre. N. Y. Tribune.

METHOD OF INSERTING AND SECURING CRANK PINS.*

SOME time since, in making some experimental machinery, it was found desirable to use a crank shaft in which the crank pin could be changed, sometimes using 8 inches throw and sometimes using 12 inches throw. That is, in a part of the experiment, the piston, which was 14 inches diameter and loaded to 250 pounds to the square inch, would have a stroke of 24 inches; then it would be changed to 16 inches, these changes being made a number of times.

It will be seen that with this pressure, whatever method of securing the crank pin might be adopted, it must be one which, when the pin was in place, must be practically unyielding and not liable to work loose; at the same time it should be one which would allow of easy removal of the pin without injury to either crank or pin.

The plan which was adopted will be readily understood by reference to the accompanying sketch.

The holes in the crank, D, were bored taper; largest at the back side. The bush, B, was also bored taper, and turned on the outside to fit the taper hole in the crank, so as to bring the edge to within about ₁/₁₆ inch of the front face of the crank. In fitting this bush, the taper hole in the crank was scraped so as to insure the absolute truth of crank pin in relation to the shaft. The pin, A, was then turned and fitted to the bush, B, so that the shoulder should be at the same distance from the edge of the bush that the face of the crank was, viz., ₁/₁₆ inch. The bush was then cut from end to end, so as to give it a chance to expand or contract, and it thus became a circular wedge between the crank and the pin. The end of the crank pin is fitted into the nut, C, care being taken that the thread is a good fit. It is better not to make pitch of the thread too coarse.

Now insert the pin, A, and place the circular wedge, B, in at the back between the pin and crank, and force it well home by means of the nut, and you have a pin as rigid as if it had been put in by means of shrinking, or forced in by hydraulic pressure, and yet one easily removed without injury either to pin or crank.

This particular pin was never subject to a continuous test in running, but it showed, under a variety of trials, that it would stand up to its work without fault.

I believe that this method employed on built-up double crank would be of great utility, especially where for any cause crank pins have to be renewed.—Boston Jour. Com.

PROTECTING IRON AGAINST CORROSION.

By H. HAUPT, Philadelphia.

FOR a period of more than ten years experiments have been made under the auspices of the Hydrogen Company of the United States to discover a simple, economical, and practical method of protecting iron and steel from all ordinary corrosive influences. A large number of patents were secured, and about $100,000 expended in the erection of plants at Washington, D. C., Newburg on the Hudson, and New York, and some of the results were of the most satisfactory character. Iron that had been treated by the processes referred to effectually resisted the action of nitro-muriatic acid and other severe tests to which it was subjected, while untreated iron was immediately attacked by the acids, and quickly destroyed. But although many of the specimens thus treated gave very satisfactory results, others proved defective, and it became apparent to the contributors to the funds that the exact conditions as regards temperature, quality, and quantity of material employed and duration of treatment had not been so accurately determined that results could be duplicated with unerring certainty—an essential condition without which no process could ever be made a commercial success.

This explanation has been considered necessary to

* Presented at the meeting of the American Society of Mechanical Engineers, at Nashville, Tenn., 1888, by C. C. Collins, Newark, N. J.
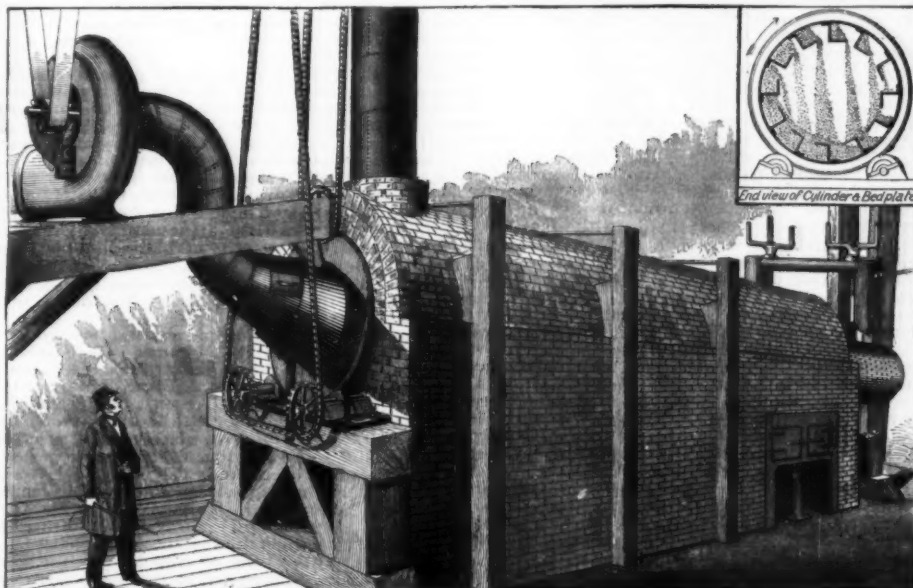
account for the fact that an industry which promised results of such extraordinary value to the public and to the parties financially interested should have been allowed to linger until the greater portion of the life of the original patents had expired. But persistency has at last been rewarded with success. The company has succeeded in securing the services of a thoroughly practical and scientific engineer, chemist, and metallurgist, Dr. Geo. W. Gesner, who was enabled to discern the defects of former treatments and to remedy them successfully by new apparatus and processes, which have recently been patented, so that while the old patents are still held by the company, they have to a great extent been superseded by more recent issues under which operations now are and will hereafter be conducted. The former treatment consisted in placing the articles to be operated upon in a close chamber, similar to a gas retort, and when heated to a temperature of about 1,200° Fahr., steam superheated in a separate furnace was introduced, followed by naphtha or other hydrocarbon vapor.

The results, as previously stated, were not always uniform, and when satisfactory, could not be duplicated under former management with certainty as to the result. All this is now changed, and the results are so uniform and certain that, with a few hours of instruction in the manipulation of the apparatus, an ordinary laborer, with no technical education, and with average intelligence, can secure results with entire uniformity. Dr. Gesner soon discerned that one of the chief defects in the former treatment arose from the fact that the steam superheated in a separate furnace and conducted by pipes into the retort was invariably cooled to the extent of several hundred degrees before admission, and came in contact with the heated iron at a much lower temperature. To remedy this defect and insure absolute uniformity of temperature between the iron and the superheated steam at the instant of contact, a peculiar but very simple form of superheater was devised and inserted in the retort itself. The result was entirely satisfactory, and after a number of experiments by him to determine the conditions necessary to insure the best treatment, the works were turned over to an employe, who has since operated them with uniform results. The plant now in operation is located at East Port Chester, near the extensive foundry of Abendroth Brothers, and consists of twelve vertical retorts with a capacity for the treatment of about 20 tons per day of the Gesner sanitary soil pipe. The time required for each charge is about two hours.

The Process.—After the pipes have been lowered into the retorts by means of a traveler, the retorts are closed for about fifteen minutes until the contents are heated to the proper temperature. Steam from a boiler at sixty pounds pressure is then introduced into the superheater, which it traverses, and from which it escapes at the temperature of the iron, upon which it acts for about one hour. A measured quantity of some hydrocarbon is then admitted with a jet of steam, followed again by a fixing bath of superheated steam, which completes the process. The most extraordinary feature of the operation is that, as Professor Gesner positively asserts, there is no pressure in the retort and no free explosive gases. The water seals attached to the retorts show only slight oscillations, but not an inch of pressure, and when the covers are removed and air admitted, there is no explosion, as there always is when free hydrogen or carbonic oxide are present, and as there always was before Professor Gesner took charge. The absence of pressure and of explosive gases is a proof that all the operations have been so nicely regulated as regards material used, quantity, and time of application, that a perfect absorption and union of the carbon, oxygen, and hydrogen with the iron has been effected. The protection thus afforded to the iron is not a mere coating, like paint, but an actual conversion, to a greater or less depth, into a new material, just as, in the process of casehardening, iron is converted into steel. When properly treated, this material does not seem to be detachable by pounding, bending, hammering, rolling, or heating. The pipes treated at Port Chester have been immersed in baths of dilute sulphuric acid and exposed to the salt air for weeks without change, while untreated pipes were quickly covered with red oxide or with sulphate of iron.

The exact chemical composition of the material produced by this treatment has not been reported upon by Professor Gesner, but it is probably a carbide, hydride, and superoxide of iron. This would seem to be a necessary result, if, as is stated, the retorts when opened contain no free gases, neither hydrogen, oxygen, nor carbonic oxide. As these gases are necessarily formed, their disappearance can only be explained on the theory that they have combined with the iron, forming the three compounds of superoxide, plumbago, and the alloy of hydrogen and iron for which Professor Gesner has proposed the name of hydron. The plant now in operation at Port Chester has been designed simply for cast iron soil pipe, but Professor Gesner is preparing plans for a more extensive plant for the treatment of wrought iron and steel, to be erected at South Brooklyn. In the application of this process each specialty will require a plant adapted to it, and a series of experiments to determine the exact conditions as to temperature, quantity, kind, duration, etc., to secure the best results, after which they can be duplicated indefinitely with any ordinary intelligence. The question is often asked, What is the effect of this treatment upon the tensile strength of the material? This can only be answered by direct tests, but if the new material should not possess the tensile strength of the untreated iron, as in wires or rods, compensation can be secured by a slight increase in diameter. It is certain that in some specimens the treatment has increased the toughness and strength by the annealing process to which the material is subjected. Sheet iron of poor quality, that would break by bending, has been rendered tough and pliable. The cost of the process is said to be about one-fourth of that of galvanizing, while the durability under similar conditions promises to be greatly extended.

THE WORRELL SAND DRIER.

THIS apparatus consists of a cylinder of steel plate, inclosed in a brick furnace. On each end of the cylinder is a cast iron flange with a half round rim, and motion is given to the cylinder by chilled friction wheels acting against these flanges. The friction wheels, as will be seen, are operated by link belts from a single countershaft overhead. The wheels at the far end of the cylinder are swung between upright posts, by two lifting screws, in order to vary the inclination of the cylinder, by which the flow of the sand through it is regulated. These friction wheels are carried on Babbitt bearings. A balanced sliding gate closes the elliptical opening in the end of furnace in which the cylinder moves up and down. The sectional view shows steel angle troughs riveted to the interior of the cylinder. These extend the whole length, and not only aid to distribute the sand, but also add to the stiffness and heating surface of the cylinder. A large exhaust fan draws air through the cylinder from the far end and discharges outdoors. A spiral iron conveyer leading from the draining bins brings the sand to the cylinder, into which it is fed through the conical spout shown in the engraving. It will be seen that the far end of the cylinder is perforated to screen the sand after it is dried, thus combining the two operations of drying and screening.

In operation the wet sand is fed through the spout shown into the cylinder, and is repeatedly taken up by the troughs and poured out again in a number of thin streams, while the air not only passes between the streams, but, owing to the rotation of the cylinder, the current passes through the streams of sand spirally, so that the sand is very thoroughly exposed to the heated air in its passage. It is claimed further that by this arrangement the temperature of the material drying is kept so low as to permit of the use of this apparatus for drying grain without scorching it. This machine embodies in a very simple manner the three absolute requirements of economical drying, namely, plenty of air, a great amount of heating surface, and a direct application of the heat. It has been in use in different parts of the country for six years and is highly spoken of. Several sizes are made, and some modifications are used for drying very wet products and fibrous materials.

A machine has been recently set up for the Millington White Sand Co., of Chicago. This sand is mostly used for making glass, and is first thoroughly washed, and after draining 24 hours, it retains nearly 10 per cent. by weight of moisture. Locomotive sand would ordinarily not carry more than one-third as much moisture. This machine was guaranteed to handle not less than 4 tons per hour, and has lately been drying twice that amount, even while the sand was frozen. The following table compares the performance of one of these driers with an ordinary railroad stove drier, and is the result of actual experiment:

	Railroad stove drier.	Worrell's No. 3 drying machine.
Pounds of wet sand dried and screened per hour	675	16,000
Pounds common soft coal consumed per hour...	24	180
Pounds water dried out per pound coal burned	1	8½
Average percentage of water in the two different sands	0·035	0·093
Men's labor required	1	3
Expense of drying one ton of sand:		
Cost of labor at 15 cents per hour	$0.44	$0.05½
Cost of coal at 12½ cents per bushel	.11 1/16	.03½
Cost of steam motive power	...	.03
Cost of interest, repairs, and depreciation	.02	.02
Total	$0.57 1/16	$0.14

Further particulars with regard to this machine can be obtained from the maker and patentee, S. E. Worrell, Hannibal, Mo.

End view of Cylinder & Bedplate

THE WORRELL SAND DRIER.

WATER GAS AS USED FOR METALLURGICAL PURPOSES.*

SOME years ago a paper was submitted to this Institute on apparatus for making water gas, by Messrs. Lowe & Strong. Since then, however, great improvements have been effected, principally by German engineers, so that the plant is now extremely simple and durable. Before entering upon the construction of the improved apparatus which is now used in Europe in the generation of water gas, a pause may be made to consider the reactions which are involved in passing steam through a mass of incandescent carbon. Steam, in passing through red hot carbon, produces a mixture of carbonic acid, carbonic oxide, and hydrogen, in which mixture the proportion of carbonic acid varies according to the temperature of the mass of heated carbon when the steam is passing through it. If this temperature is high enough, there is no carbonic acid produced at all, only carbonic oxide and hydrogen, so that the water gas which is obtained is composed theoretically as under:

	By volume.	By weight.
CO, 50 per cent		94 per cent.
H, 50 per cent		6 per cent.

As the temperature decreases, the proportion of carbonic acid increases, while the proportion of carbonic oxide in like manner decreases, so that finally the result would be the production of a gas composed as under:

	By volume.	By weight.
CO2, 33 per cent		92 per cent.
H, 66 per cent		8 per cent.

Carbonic acid passed through carbon begins to be decomposed into carbonic oxide at a temperature of 550° C.; and at a temperature of 950° C. the production of oxide rises to 94 per cent., while at 1,000° C. the transformation is completely obtained. Similar results are realized on passing steam through incandescent coke; at a temperature of 500° C. its decomposition to hydrogen and carbonic acid is complete. From 1,000° C. to 1,200° C. the carbonic acid is converted into carbonic oxide.

The whole reaction is, therefore, as follows: The decomposition of steam produces hydrogen and carbonic acid, and by continued contact with the incandescent coke, the carbonic acid is transformed into carbonic oxide. It may be stated that a cubic meter of water gas develops in round numbers 3,000 cals. Theoretically, the temperature produced is 2,839° C. Combustion of the carbonic oxide to carbonic acid causes 3,021 cals., that of the hydrogen 2,649 cals. The first figure therefore constitutes a mean between the others. In regard to this, it may be mentioned that the figures given for the first and the third of these temperatures are evidently exaggerated. The slight inaccuracy must be attributed to the supposition that, while at these high temperatures, the specific heat remains constant in the case of steam, as in the case of carbonic oxide; but this cannot be the case, at least as far as steam is concerned, seeing that the experiments of MM. Langen and Mayer have proved that with this vapor dissociation commences at 1,200° C., while with carbonic oxide no change is perceptible even at a temperature of 1,690° C. A word should be said about a reaction which occurs also in the manufacture of water gas, viz., that of carbonic oxide on steam. In heating a mixture of carbonic oxide and steam, a reaction is set up (according to the experiments of Professors Nauman and Pistor) on carbonic oxide, which begins at a temperature of about 600° C., and produces carbonic acid and hydrogen. With an augmented temperature this reaction increases, so that at 900° C. there is produced 10 per cent. of carbonic acid. According to experiments made at Essen in the water gas generator, where ordinary steam was replaced by a mixture of water gas and steam, and the mixture then passed through the generator at a high temperature, the whole of the carbonic oxide contained in the water gas was finally reduced to carbonic acid. As one kilo. of oxygen, in reducing carbonic oxide to carbonic acid, gives more heat than when it is employed with hydrogen to form water, the operation which we have described is accompanied by an evolution of heat.

It will now be seen how these facts, derived from experiments, can be practically utilized. In all water gas apparatus the principal part consists of a generator, in which the fuel, by the aid of an air blast, is raised to a high temperature, to be afterward cooled by a jet of steam for the production of water gas. During the heating up by means of the blower, Siemens or generator gas is produced, while the cooling effected by the steam produces water gas. The characteristic, therefore, of the water gas generator consists in pro-

* A paper read by Mr. A. Wilson, before the Iron and Steel Institute, on May 9, 1888.—*Industries.*

ducing alternately Siemens gas and water gas. According to the use which it is desired to make of the Siemens gas, the fuel which is used, and the manner of passing the steam or passing the air, or *vice versa*, there has arisen a combination of apparatus of different construction. A description will be given of one among these. At the beginning of the operation the gas is entirely free from carbonic acid and steam. In proportion as the mass of combustible is cooled, the gas acquires a larger quantity of one or the other. The passage of 1,100 liters of gas into a condenser yields 34 cm. of water, which is equivalent to 4 per cent. by weight. The fuel employed by preference in Germany is the small coke easily obtained from the residue of the fires of puddling or heating furnaces, or coke obtained directly from coke ovens or gas works.

FIG. 1.

In any case, the percentage of ash varies from 10 per cent. to 30 per cent.; frequently it is from 15 per cent. to 20 per cent. It is desirable, then, to construct the generating apparatus in a form from which large quantities of cinders may be easily withdrawn, and to make it durable. This problem has been resolved by the adoption, in the lower part of the generator, of a water ring, which obviates the use of a grate, and protects that part most exposed to heat and to destruction by the slag. This water ring is arranged so that beneath it there is an open annular space, round which the air enters during the blowing operation. It is also by this that the water gas escapes which is produced by the next process. The slag is thus deposited on the conical surface of the fuel, in a covering which extends up to the opening of the water ring, and the cinders may be easily withdrawn by means of four cleaning doors. The cleaning out is done every six hours, and occupies from fifteen to thirty minutes, according to the quantity of cinder produced. In blowing in the air, the cold blast arrives against the surface of the lower part of the ring and cools it, and so carries away the radiant heat thrown off at the bottom. This radiant heat, further, only exists, or has no importance, except just after cleaning, when the slags which have been deposited have been removed. The almost immediate formation of a new layer of cinder or slag then prevents much loss by radiation.
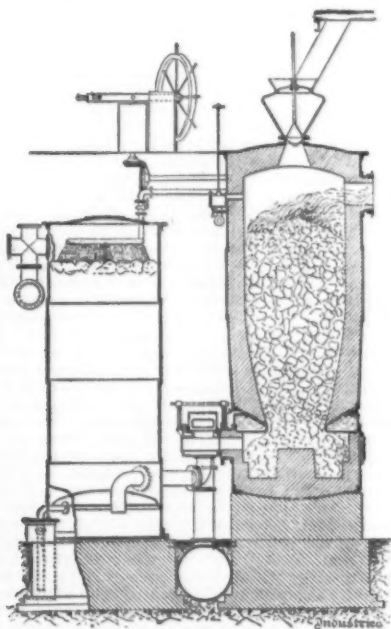

FIG. 2.

The matter is different during the operation of gas making; the water gas escaping at a temperature of from 1,300° C. to 1,500° C. imparts its heat to the lower part of the water ring, and this is carried off by the cooling water; but this quantity of heat would in any case be lost, seeing that it must be disposed of before the entrance of the gas into the gas holder.

It matters little, therefore, whether this abstraction is commenced by the water ring or whether it is effected entirely in the scrubber. The first water gas plant successfully put to work for practical use in Europe was erected by Messrs. Schulz, Knaudt & Co., at Essen, and consisted of two generators, each capable of pro-

ducing 10,000 ft. of water gas per hour. These generators are about 6 ft. 6 in. external diameter by 18 ft. high. The gas, on leaving the scrubber, passes by a cast iron pipe to a gas holder of about 40 ft. diameter, and situated about fifty yards from the generator house. From this holder the gas is led away by mains to the various welding furnaces; and another portion is taken from the holder expressly for lighting purposes, and this portion only is passed through the purifier to remove carbonic acid and sulphur compounds. The generation of the gas is so rapid that, when the steam is passed into the fuel, the holder rises some feet at one operation, and may easily be observed to be rapidly ascending. As to the other details of the apparatus which is at work at Essen, in the works of Messrs. Schulz, Knaudt & Co., it should be stated that it was constructed on the system of Strong's patent, at least so far as concerns the employment of a double regenerator, heated by the hot gas which escapes when the air is blown in, intended to superheat the steam serving for the production of water gas. And this steam did not pass through the incandescent mass of coke except in a superheated state. In working the apparatus it was soon found that the complete combustion of the Siemens gas had a tendency to cause a rapid destruction of the bricks in the regenerator, and this not only on account of the very high temperature, but also on account of the cindery dust—the combustible containing as much as 25 per cent. of ash.

When this was ascertained, the top supply of air to the regenerator was stopped, and the regenerator chambers were only heated by the sensible heat in the Siemens gas; that is to say, to a temperature of about 500° C. In consequence of this, the steam was not highly superheated, but the consumption of fuel did not increase in the proportion which had been feared; further, the yield of the apparatus increased to a notable degree, because the quantity of air furnished by the blower, instead of being divided into two parts, for the top supply and the bottom supply, was entirely utilized for the latter, and the heating did not require more than half the time previously employed. This had the effect of doubling the production of water gas, *i. e.*, a production which at first not being more than 120 cb. m. per hour, rose to 250 cb. m. to 300 cb. m. per hour, without any sensible increase in the consumption of fuel. After being transformed to gas by the action of the fuel, of which the lowest part is heated to whiteness, while the upper part is of a dull red, the steam passes by way of the first named portion through a hydraulic lute communicating with a coke scrubber. Cooled in this manner, the gas enters the gas holder. In order to prevent any danger of the blast passing by leakage along with the gas, an ingenious and highly successful slide valve was introduced by Mr. Blass, of Essen. The construction of this is indicated on diagram, Fig. 1, by which it will be observed to consist of a D valve, sliding on three ports, and provided with an open water trough to keep it cool; while in the face of the valve between the ports grooves are cut, so that any leakage of air or gas respectively must pass to the atmosphere instead of forming mixtures in the pipes, which might prove dangerous. When once the charge is heated up, the steam is admitted for the production of water gas for about five minutes, when the valves are reversed simultaneously, and the charge is blown up to restore heat during about ten minutes, the various movements of the apparatus being all controlled in a convenient manner by one lever or hand wheel. Owing to this construction the generator is converted into a machine, and for three years its mechanism has worked with perfect regularity, while the repairs needed by the brick lining have been of a most trifling description. Employing ten minutes for blowing up, and five minutes for the manufacture of water gas, each generator produces from 250 to 300 cub. m. per hour. The carbonic acid never exceeds 4 per cent., so that the final result is a gas composed of 5 per cent. nitrogen, 4 per cent. carbonic acid, 41 per cent. carbonic oxide, and 50 per cent. hydrogen. The next plant put to work was erected at the Witkowitz iron and steel works, in Austria, and consisted at first of two generators, each capable of making 20,000 ft. of water gas per hour (the construction of these is indicated by Figs. 2 and 3), also the necessary scrubber and gas holder. In this case the water gas is used for driving open hearth steel melting furnaces, and for lighting the works on the incandescent system, which will be shortly described, while the generator gas is used for firing the boilers. As regards the construction of the steel melting furnaces, it may be observed that only two regenerator chambers, instead of four, are employed, and this arrangement tends to simplify the construction of the furnace, and reduce the wear and tear and first cost. With only one pair of regenerators, the temperature is so high that very great rapidity is attained in working, no less than five charges being got out in twenty-four hours, with a proportion of scrap of less than one-third. Five hundred cubic meters (=17,655 cub. ft.) of water gas is used per ton of ingots; and the manager, Mr. J. Langer, expresses himself as convinced that there is a great advantage in using water gas for steel melting, always provided that the generator gas which is produced at the same time is employed for boiler firing or similar purposes.

There is no doubt that, if the furnaces were of a larger size, such as are generally used in this country, say working from ten to twenty ton charges, the consumption would be very much smaller. Water gas is also employed at Witkowitz for heating the billet furnaces, the consumption being 270 cub. m. (= 10,000 cub. ft.) per ton of steel billets rolled. At Witkowitz the fuel used is small coke, and the water gas produced amounts to about 33,000 cub. ft. per ton of fuel, along with about 130,000 cub. ft. of generator gas, which, as before mentioned, is used for firing boilers. At Hoerde, a very extensive water gas plant has been erected by Mr. Massenez, who intends to use the water gas generally for melting and heating, also for lighting the works, and the generator gas for boiler firing.

A similar plant has been erected by Mr. Sampson Fox, at the Leeds Forge Company's works, for welding flues and illuminating. A smaller generator, for the production of about 2,000 ft. of water gas per hour, is shown in Fig. 4. As this is designed particularly for lighting purposes, the greatest simplicity was aimed at in its design. The draught is obtained by a small steam jet exhauster sucking out at the top, and this combination possesses the following advantages: During the

blowing up it is impossible for the air to pass the hydraulic seal and escape to the gas holder, this seal being sufficiently heavy to resist the suction without materially augmenting the back pressure during the manufacture of gas; the suction also allows of the extraction of ashes during the heating up without work being stopped.

The small opening through which the charging is done serves alternately for the chimney. A plate provided with three openings radiating from a pivot is turned by means of a hand wheel into three given positions. In the first there is a chimney provided with the aspirator, in the second there is a charging hopper,
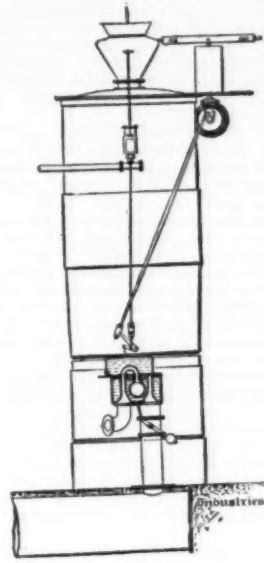

FIG. 3.

and in the third there is a cover plate. To work the apparatus, therefore, the attendant has nothing to do but to turn his wheel to right or to left during intervals which are exactly determined by experience, or, more particularly, by analysis. This apparatus consumes 3 lb. of coke, containing 14 per cent. of ash and 5 per cent. of water, in making 35 cub. ft. of gas. There is included in this figure such coke as is uselessly consumed during the night. The blowing up is continued ten minutes, after which the manufacture of gas occupies five minutes; the quantity of water used by the water cooling ring is about 750 gallons per day of twenty-four hours. It should also be mentioned that the water runs during the night as well as when the gas is being made.

The first generator of this size was erected by Mr. Pintsch, whose name is well known in connection with railway carriage lighting, and it is used for illuminating his works at Furstenwald, near Berlin, as well as the railway station adjoining, with all the signal lamps, etc. Another of the same size has been erected by the author at Stafford, and may be seen at work any time. It should also be mentioned that water gas plants are successfully at work at the Terni Steel Works, in Italy, and in the engineering shops of Messrs. Sulzer Brothers, Winterthur, Switzerland. Water gas is made in America almost exclusively for lighting by carburation. In Europe this has not been practiced, partly on account of the price of petroleum refuse. In the first apparatus constructed in Germany there was no
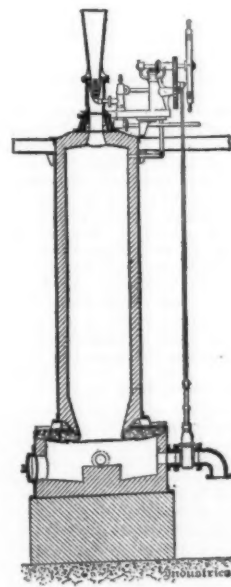

FIG. 4.

object in view but the production of heating gas for metallurgical work, or that which limited its employment to heating and melting purposes. It was then found that the water gas burnt without an excess of air, and produced so high a temperature that a platinum wire was melted by being placed in the open flame; this corresponds to a temperature of 1,700° C.—the highest temperature recorded by Rosetti with a Bunsen burner using coal gas being only 1,350° ("Annual Report of Chemical Technology, 1887"), a heat which does not approach that of water gas. According to the experiments of Aime Witz ("Annals of Chemistry and Physics"), lighting gas only develops 4,000 cals. to 5,000

cals. instead of 6,000 cals., as before supposed. It accrues from this, that this gas, owing to the rapidity of its combustion, has a reduced flame area, and consequently is less cooled on the surface by radiation. A flame of ordinary gas, with the same speed of consumption, possesses a surface six times as large as the water gas flame; and although a cubic meter of lighting gas produces theoretically double the heat by its combustion, the temperature of the flame is at the same time much less. Thus, in a small tinal furnace, Bessemer steel was easily melted by water gas and cold air, and poured out in a perfectly fluid state.

But the best proof which it is possible to have of the high temperature of water gas is found in the incandescent magnesia light on Fahnejelm's system. This constitutes the very best system of gas lighting by incandescence, and it may be described as follows: The flame heats a comb, composed of little magnesia rods, to whiteness, producing a light superior to the incandescent electric light, but without having the bluish tinge of the arc lamp, and consequently resembling more nearly the splendor of sunshine than any other existing system of lighting. This light possesses, besides, the advantage of absolute steadiness. This follows from the circumstance of having a certain mass of matter in an incandescent state, requiring an appreciable time to cool it and to effect a variation in the power of the light, and consequently preventing any irregularity in the luminosity of the flame. In order to obtain the same quantity of light by this system, it is necessary to consume the same quantity of gas as of coal gas. With a consumption of 150 liters per hour (= 5·3 cub. ft.), a magnesia comb gives at first a photometric power of from 20 to 22 candles; after fifty hours it gives but 15 candles; and after one hundred hours only 10. The combs cost 1½d. each, so that their consumption amounts to about one farthing per hour, and per cubic meter of gas consumed the price amounts to one pfennig (1·25 centimes), equal to 2¾d. per 1,000 cub. ft. The magnesia comb is supported by a wire, slipped into a socket on the carrier of an ordinary gas bracket. The burners used are exactly the same as those used for town gas, and so are the globes and all the fittings concerned.

In substituting lighting by incandescence with water gas, therefore, no changes whatever are necessary in the existing pipes and gas fittings. The magnesia combs, being quite loose, may be removed and replaced in a moment. As before mentioned, this system of lighting has been adopted with great success at several large works on the Continent, and it is also largely used in America; and seeing that it offers a convenient and beautiful means of illuminating, possessing the convenience of town gas with the brilliancy of the electric light, at less than half the cost of either, it must commend itself for adoption in this country also. On these grounds, it was thought by the author that some mention of this system of lighting in connection with this paper would be of interest to the members of the Institute, although perhaps the subject possesses the greatest importance to those present from a metallurgical standpoint.

It may be well, before concluding, to revert shortly to the economic aspect of the question of the use of water gas in large quantities for steel melting and such purposes, as compared with the cost of the gaseous fuel at present generally used for the same purposes. The most approved and economical types of generator for making producer gas are worked by a mixture of air and steam, and make in reality a mixture of producer and water gas simultaneously. The water gas generators are alternately worked by air by itself to make producer gas, and then by steam by itself producing water gas; thus the same gases are ultimately produced by each system, but in the water gas plant they are separated.

As the cost of the fuel and attendance is about the same in each case, as is also the loss of heat by external radiation, there can be no material difference in the value of the heating gases produced by either system, at a given cost for fuel and otherwise; thus in the manufacture of water gas, when this is averaged together with the producer gas necessarily generated in the operation, the cost of the water gas is, as demonstrated below, practically the same as that of the mixture known as generator or producer gas; and it cannot, therefore, be more expensive to use water gas for any operation than producer gas, when the value of the latter, also produced by the water gas plant, is credited, as it can be in any works where there are boilers, etc., to be fired. At the same time the separation of these gases, so as to have the water gas by itself, has very important collateral advantages and economies which are of great value. In the manufacture of water gas, if the water gas and the producer gas, also made separately, are subsequently mixed, the analysis of the mixture is substantially almost identical with producer gas made in the best and most economical manner, thus proving that the heating value of the gas made from the fuel is the same by each system, and the value received practically equal. Producer gas: One ton of slack coal, at 5s. 6d. per ton, yields of this gas about 150,000 cub. ft., equals per 1,000 cub. ft. 0·44d., or slightly under one-half penny per 1,000. Water gas: One ton of inferior coke, at 8s. 3d. per ton, yields of this 55,000 cub. ft. of pure water gas, and about 140,000 cub. ft. of generator gas equals 175,000 cub. ft., equals per 1,000 cub. ft. of the whole of the gas produced 0·43d., or slightly under one halfpenny per 1,000. The cost of steam raising and labor is the same in each system for the same analysis of mixed gases.

SIR WILLIAM THOMSON'S COMPOSITE ELECTRIC BALANCE.

By Thomas Gray, B.Sc.

A NEW form of electric balance has recently been introduced by Sir William Thomson, which can be adapted either for the measurement of volts, of amperes, or of watts. In the forms hitherto made, the range for current is from ¼ of an ampere to 500 amperes for continuous currents, and from ¼ of an ampere to 250 amperes for alternating currents. The range for volts is, as in all such instruments, only limited upward by the resistance available; but, as the resistance of the potential coils is about 40 ohms, the lowest potential which can be accurately measured is about 1 volt. These coils are of copper wire, and, in

consequence of the high temperature variation of that metal, very high accuracy is not attainable for such low potentials as necessitates the use of the balance without any resistance in its circuit external to its coils. Potentials of from 10 volts upward may, however, be measured with almost perfect accuracy with this instrument by introducing sufficient non-inductive resistance of platinoid or German silver wire into the circuit. For the measurement of potentials on alternate current systems there should be at least 500 ohms of non-inductive resistance in the circuit.

The general form and construction of the balance will be better understood by reference to Fig. 1. Two coils of silk-covered copper wire, A B, made in the shape of anchor rings, are fixed to the two ends of a light aluminum frame, C, which forms the beam of the balance. This beam is suspended in such a way that the planes of the coils are approximately horizontal, by two flat ligaments, one of which is shown at D, consisting of twenty copper wires, each about ⅟₁₀ mm. diameter. The suspension ligaments are about 1·5 cm. long, and are attached at their lower ends to two insulated brass tubes, carried on a trunnion, E, which passes across the middle of the aluminum frame. Their upper ends are attached to round pins, F, fixed horizontally, and with their length parallel to the trunnion, in two brass uprights, which are screwed to the sole plate, G, of the instrument. The suspension ligaments serve the double purpose of forming a flexible elastic joint about which the beam can freely turn, and of conveying the current into and out from the coils fixed to the beam. These movable coils are about 8 cm. mean diameter, and the cross section of the ring is about 1 sq. cm. Symmetrically placed with reference to each other and the suspended coil, one above and the other below the coil on the right hand end of the beam, are fixed two coils, H I, of silk-covered wire similar to that used for the movable coils. These coils have about the same mean diameter; but the cross section is rectangular, nearly square, and about 4 sq. cm. in area. Similarly placed with reference to the coil on the left hand end of the beam, are fixed another two coils, J K, which are capable of carrying strong currents. When the instrument is specially designed for continuous currents, these coils are made of copper ribbon of sufficient thickness to carry 500 amperes safely. When the instrument is intended for alternating currents, the conductor consists of a rope of thin copper wires, each of which is silk-covered to insulate it throughout its length from the others. The ends of all the wires are soldered together; and in order to avoid, as far as possible, error due to irregular distribution of the current across the section, the rope is given one turn of twist for each turn which it makes round the coil. Two turns of this rope is sufficient for each coil, and the maximum current is 250 amperes. The bobbins on which the fixed coils are wound, and the sole plate of the instrument, are made of good insulating slate, and the beam of the balance is cut at each end, so as to avoid Foucault currents in the frame work and sole plate.

To prevent excessive shake during the use of the instrument and for convenience of portability, capstan-headed stop screws, L, are attached to the supports at the ends of the fixed scale, M, and to an upright at the middle of the suspension trunnion. In the ordinary use of the balance these stop screws are turned until they are just clear enough of the movable scale, N (which forms the front bar of the beam), and of the trunnion, to allow the beam to swing freely. For

packing, the trunnion screws are turned back, the beam lifted up against two stops above the trunnion, and two packing pieces containing V's for the trunnion slipped between them and fixed by the screws, while the screws at the end of the scale, M, are screwed so as to gripe the movable scale. The instrument may then be carried about, or sent anywhere, with perfect safety under ordinary usage.

The method of using this balance is similar to that of the other balance already fully described in these columns. The instrument having been leveled, and the stop screws adjusted so as to limit the shake, as above indicated, the proper weight is put on the carriage, P, and the corresponding counterpoise weight in the trough, Q, and the zero adjusted. Before making this adjustment the carriage and weight are moved to the zero of the movable scale by pulling the cords, R S, which move the slider, T. Having set the index of the carriage exactly to the zero line, using the lens which is supplied with the instrument, if necessary, the flag, U, should be turned by moving the handle, V, until the index, W, on the end of the scale points to the middle one of the five black lines on the vertical scale, when the beam is allowed to swing freely and come to rest. Should by any accident the flag not have sufficient power, the mass, y, on the back bar of the beam may be slipped a little to one side, until the flag is able to make the adjustment. A second vertical scale, Z, is fixed at the left hand end of the beam, and the index, A, should point to the middle line of it when the index, W, points to the middle line of X. The two scales are placed in the instrument to allow the observer to see whether by any accident the ligament has been elongated since it left the maker's hands. Such an
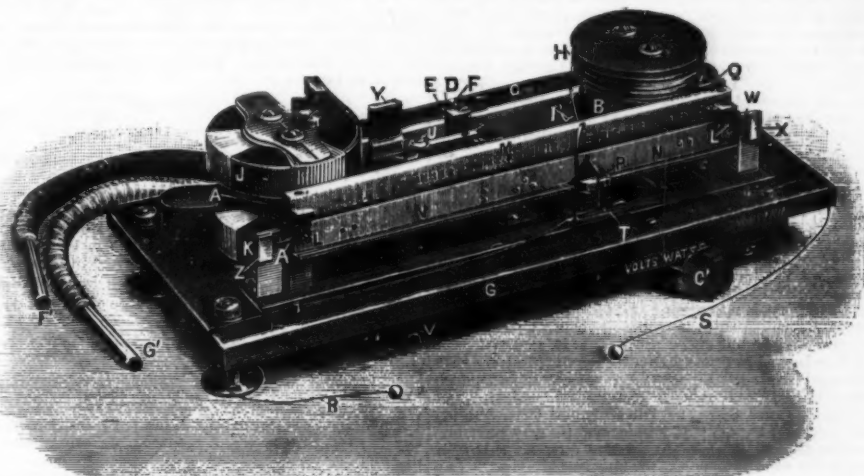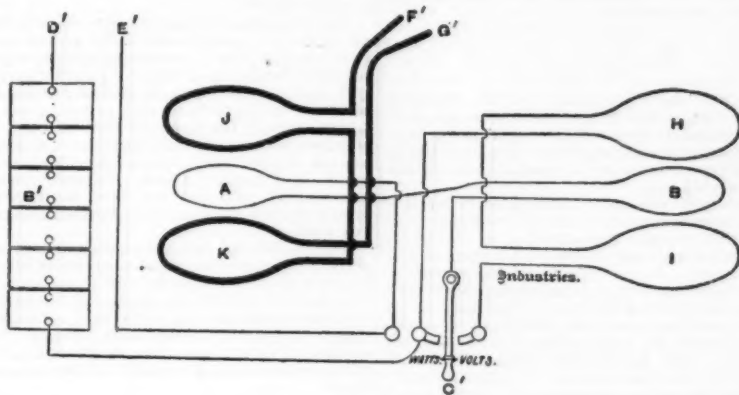

FIG. 1.

FIG. 2.

COMPOSITE ELECTRIC BALANCE.

elongation of the ligament may take place with rough usage, and a slight change of constant would be the result; but it very rarely occurs. The mode of using the balance for the different classes of measurements will be more readily understood from the diagram, Fig. 2. In this diagram, B, represents a set of non-inductive resistances of suitable magnitude for the potential of the circuit to which the suspended coils are to be connected. Suppose, in the first place, that the balance is to be used as a voltmeter. The handle, C_1, of the switch is turned to volt, and the electrodes, D_1, E_1, connected to the points whose difference of potential is to be measured. The current then flows through the electrode, E, and the suspended coils, A B, to the switch, then from the " volt " terminal through the fixed coils, HI, to the " watt " terminal, and from that terminal through the resistance B_1 to D_1. As the result of this current, the right hand end of the beam is deflected upward, and the weight has to be pulled toward the right in order to restore the balance. The distance through which the weight has to be moved gives the couple produced by the amperean forces between the coils, and from the constant supplied with the instrument the potential between D_1 and E_1 is deduced. It will be seen that by this method of using the balance, small currents may be measured. It is, in fact, a modified " centiampere " balance. The maximum current these coils are expected to carry is 1 ampere, and currents from ⅟₁₀ to 1 ampere may be measured in this way.

Next suppose the instrument is to be used as a watt-meter. The switch handle is turned to " watt," the electrodes, D_1 E_1, connected to volt, and the electrodes, F, G_1, of the current coils, J K, connected to the two sides of a break in one of these mains. The whole current passing that break flows through

the coils, J K, and a current proportional to the difference of potential between the mains flows through the movable coils, but not through the fixed fine wire coils. The left hand coil of the movable system is thus acted upon by a force proportional to the product of the difference of potential between the mains and the current passing through them—that is, proportional to the rate of working in the circuit.

For the measurement of current the strength of which exceeds one ampere, the instrument is used heterostatically—that is to say, a constant measured current is passed through the suspended coils, and the current to be measured is passed through the fixed current coils. The connections for this use of the instrument are the same as for the measurement of watts. When a constant e.m.f. is available, the current passed through the suspended coils may be measured by first turning the switch to "volt," and adjusting an external resistance so as to obtain the required current, and then turning the switch to "watt," and at the same time increasing the external resistance by an amount equal to the resistance of the fixed coils, H I. Generally, however, a separate indicator or galvanoscope requires to be used in circuit with the suspended coils of the balance when it is used for the measurement of amperes. This indicator can, of course, be standardized by the balance itself, arranged for the measurement of small currents, and it need not be capable of measuring change of current, but it should be sensitive to such change.

In standardizing this balance two sets of weights are determined, one of which, generally marked $v\,w_1$, $v\,w_2$, $v\,w_3$, is used when the instrument is connected as a voltmeter or a centiampere meter. The current corresponding to any displacement of the weight is, in this case, half a centiampere, one centiampere, and two centiamperes per division of the fixed scale for the three weights respectively. The other set is adjusted to measure the current flowing through the fixed coils, J K, when a quarter of an ampere is flowing through the suspended coils. There are two weights in this set, marked $w\,w_1$ and $w\,w_2$. The smallest weight has to be displaced one division of the movable, or equal division, scale for each tenth of an ampere flowing through the fixed coils, J K, and the larger weight has to be displaced one division of the movable scale for each half of an ampere flowing through these coils.

This second set of weights also serve for the watt measurements, as all that requires to be known in order to allow the constant to be deduced is the resistance in the circuit of the suspended coils. Suppose this resistance to be equal to R, and the number of volts between the terminals to be V. Then the current through the suspended coil circuit = V R, and the constant of the instrument requires to be divided by this quantity and multiplied by the number of amperes used when the constants were determined—that is, $\frac{1}{4}$ in this case. Hence the constant supplied with the instrument divided by 4 V/R will serve in any particular case for the measurement of the current through the final coils or the circuit of the installation. Let for any particular measurement the reading on the scale of the beam be N divisions, and the constant supplied for the weight used be C, and we get for the current in the circuit :

$$A = \frac{C\,R\,N}{4\,V}$$

Now the number of watts being used in this circuit is equal to $A \times V$, that is, to C R N/4, or the constant to be used for the calculation of watts is equal to the constant supplied for the measurement of amperes multiplied by R/4 where R is the total resistance in the circuit of the suspended coil.

In connection with the use of instruments of this class for the measurement of potentials, or of energy in alternating current circuits, the question of the effect of the self-induction and the mutual induction of the coils of the instrument on its indications has always to be considered. Consider first the measurement of volts by the instrument just described. The suspended coils are about 4 cm. mean radius ; the diameter of the cross section is about 1·1 cm., and they each contain on the average a little under 400 turns. The coefficient of self-induction of such a coil is approximately 18×10^6 cm. The fixed coils have about the same mean diameter, and the section is square, 2 cm. to the side, and they contain each about 670 turns. The coefficient of self-induction of this coil is about 36×10^6 cm. The mutual induction between the movable and fixed coils is zero, as the fixed coils are at equal distances on opposite sides of the movable coil, and the one attracts while the other repels. There remains the mutual induction between the fixed coils, the mean distance between which is 5 cm. This is of opposite sign to that of the self-induction ; but as it is small compared with it, and is favorable to the instrument, we may neglect it. Taking, then, the sum of the self-inductions of the two movable and two fixed coils, we get for the induction coefficient of the instrument 108×10^6. Let R be the total resistance of the circuit supposed, with the exception of the instrument, to be non-inductive ; E the electromotive force at time, t, and C the current flowing at that time ; and L the coefficient of induction. Then

$$R\,C = E - L\,\frac{d\,C}{d\,t}$$

Assuming that $E = E_0 \sin \frac{\pi}{r} t$ where E_0 is the amplitude of the alternating e. m. f., and 2 r its period, we get

$$L\,\frac{d\,C}{d\,t} + R\,C = E_0 \sin \frac{\pi}{r} t = 0 \dots\dots\dots(1)$$

From this we deduce that

$$C^2 = \frac{1}{2}\,\frac{E_0{}^2}{R^2 + \pi^2 \frac{L^2}{r^2}}$$

Now, since the force between the movable and the fixed coils is proportional to the square of the current, the readings for volts deduced from it will be proportional to $E_0 / \sqrt{R^2 + \pi^2 L^2/r^2}$, and thus the indications of the instrument will be diminished, by induction, in the ratio of R to $\sqrt{R^2 + \pi^2 L^2/r^2}$. The resistance of the coils of the instrument is a little over 40 ohms, and

the additional resistance is usually made equal to six times the number of ohms that there are volts to be measured. On a 100 volt circuit, alternating at the rate of two hundred reversals of the potential per second, we should have the ratio of the indicated potential to the true potential equal to

$$640 \times 10^2 / \sqrt{640^2 \times 10^2 + 3\cdot1416^2 \times 108^2 \times 10^{12} \times 200^2}$$

equal to 0·9945 ; that is to say, the indicated potential would be fully a half per cent. too low. The rate of alternation is here taken rather higher than the usual practice, and the induction coefficient somewhat overestimated, so that we may conclude that for ordinary purposes such an instrument forms a reliable voltmeter. For measuring the number of volts in the supply mains of transformer circuits, the resistance, R, becomes so great that the indications for alternating and continuous e. m. f.'s are absolutely the same, so far as they can be measured.

For the measurement of watts, the induction coefficient is the sum of the self-induction of the two suspended coils, or, approximately, 36×10^6. The effect of mutual induction between the fixed or current coils and the suspended coils is zero, since they are symmetrically placed one above and the other below the suspended coil, and the current made to flow in opposite directions in the two. From equation (1) above we have by integration

$$C = A\,e^{-\frac{R}{L}\,t} + \frac{E_0\,r}{\sqrt{R^2\,r^2 + \pi^2\,L^2}}\,\sin\left(\frac{\pi}{r}t - \varepsilon\right) \text{ where}$$

$$\sin \varepsilon = \frac{\pi\,L}{\sqrt{R^2\,r^2 + \pi^2\,L^2}}, \text{ and } \cos \varepsilon = \frac{R\,r}{\sqrt{R^2\,r^2 + \pi\,L^2}}$$

This quantity ε gives the difference of phase between the current flowing through the coils and the e. m. f. on their terminals. Taking the same values for R and r as before, we find

$$\sin \varepsilon = \frac{3\cdot1416 \times 36 \times 10^6}{\sqrt{620^2 \times 10^{12} \times 0\cdot005^2 + 3\cdot1416^2 \times 36^2 \times 10^{12}}} = 0\cdot000011$$

which gives ε equal to a little over two seconds of angle. It is therefore clear that if the e. m. f. is as much as 100 volts, the instruments will give to a very high degree of approximation the true watts, so long as the difference of phase between the current in the fixed coils and the e. m. f. on the supply mains does not approach 90° nearer than a few minutes of angle—that is, so long as there is any sensible amount of work being done in the circuit.—*Industries.*

THE GRAMOPHONE—ETCHING THE HUMAN VOICE.*

By Emile Berliner.

THE last year in the first century of the history of the United States was a remarkable one in the history of science.

There appeared about that period something in the drift of scientific discussions which, even to the mind of an observant amateur, foretold the coming of important events.

The dispute of religion *versus* science was once more at its height ; prominent daily papers commenced to issue weekly discussions on scientific topics ; series of scientific books in attractive popular form were eagerly bought by the cultured classes ; popular lectures on scientific subjects were sure of commanding enthusiastic audiences ; the great works on evolution had just commenced to take root outside of the small circle of logical minds from which they had emanated, and which had fostered them. Scientific periodicals were expectantly scanned for new information, and the minds of both professionals and amateurs were on the *qui vive.*

Add to this the general excitement prevailing on account of the forthcoming centennial celebration, with its crowning event, so dear to this nation of inventors, the world's exhibition, and even those who did not at the time experience the effects of an atmosphere pregnant with scientific ozone can, in their minds, conjure up the pulsating, swaying, and turbulent sea of scientific research of that period. Science evidently was in labor.

The year 1876 came, and when the jubilee was at its very height, and when this great city of Philadelphia was one surging mass of patriots filling the air with the sounds of millions of shouts, a still small voice, hardly audible, and coming from a little disk of iron fastened to the center of a membrane, whispered into the ear of one of the judges at the exhibition and one of the greatest of living scientists, the tidings that a new revelation had descended upon mankind, and that the winged and fiery messenger of heaven's clouds had been harnessed to that delicate, tremorous, and yet so potent form of energy called the human voice.

The speaking telephone had been born.

The stimulus which this event gave to science can best be measured by the enormous advance made since, especially in that now most prominent branch, electricity, and I will show further on how, immediately following it, our sister republic across the ocean answered the magic touch by the conception of another invention, the scope of which cannot to-day be measured yet, and which only just now is starting on its career of usefulness among the practical arts.

In order to show the influence which these two inventions had upon each other, and how their respective development came about in parallel steps, permit me, before entering upon the new methods which I am to bring before you to-night, to pass in rapid review on the principal events in the history of the transmission of speech electrically and of recording and reproducing the same mechanically.

In 1854, Charles Bourseuil, with more than usual boldness, advanced the idea that two diaphragms, one operating an electric contact, and the other under the influence of an electro-magnet, might be employed for transmitting speech over telegraphic distances. "Speak against one diaphragm," he said, " and let each vibration break or make the electric contact, and the electric pulsations thereby produced will set the other diaphragm vibrating, and the latter ought then to reproduce the transmitted sound." Outside of the

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* A paper read at the stated meeting of the Franklin Institute, May 16, 1888.

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fallacy which his theory contained in the assumption of breaking the contact, instead of merely modifying the same, Bourseuil's paper, in speaking of the diaphragm, laid stress upon stating that "if one could be invented so movable and flexible as to answer to all the undulations of sound." He evidently desired extreme flexibility, and diaphragms constructed on that principle proved fatal to the efforts of many subsequent experimenters ; even at first to Mr. Bell, who, like Bourseuil, borrowed the idea from the flexible *tympanum membrani* of the human ear, and who overlooked the important modifications which the vibrations undergo, before reaching the auditory nerve, by the series of muscular hinges in which the various bony accessories of the ear are mounted, and which act as elastic dampers against the *tympanum membrani.*

Bourseuil's ideas were immediately reprinted from French journals in other countries, and among the first was a prominent German semi-weekly journal, printed in Frankfort on the Main, the *Didaskalia,* which, on September 28, 1854, under the heading "Electrical Telephony," published a leading article, giving a full account of Bourseuil's ingenious and wonderful conception.

Frankfort was then a city of about 60,000 inhabitants, and among other institutes of learning, it supported a physical society, which counted, at the time of this publication, among its active and most zealous members an enthusiastic young teacher named Philip Reis, who, five years afterward, actually made an apparatus such as indicated by Bourseuil (who had since died without executing his idea), and which apparatus has since become known as the Reis telephone.

I will not now enter upon any controversy as to the scope of this invention, regarding the possibility at the present day to transmit speech with the same. It may suffice to state that, when the news of the Bell telephone reached the learned men of Germany, some of the very first scientists in Berlin, who knew all about the Reis apparatus, doubted the possibility of the performance as represented by the American press. It is also now a matter of history that in the late decision in favor of Mr. Bell, the United States Supreme Court was unanimous so far as the Bourseuil-Reis apparatus was concerned.

While Bourseuil's conception was being digested by Reis, another invention, having also a membrane diaphragm as its motive principle, was patented in France in 1857. This was the phonantograph, by Leon Scott, which had for its purpose the recording of sound undulations upon a cylinder rotated by hand and moved forward by a screw. The cylinder was covered with paper, this was smoked over a flame, and a stylus attached to the center of a diaphragm, under the influence of words spoken into a large barrel-like mouthpiece, would trace sound vibrations upon the smoky surface. Scott also employed an animal membrane for his diaphragm, and took pains, by means of an attachment called a subdivider, to make the vibrations appear as large as possible. This subdivider, however, became the prototype of the dampers in subsequent apparatus, like the Blake transmitter and the Edison phonograph.

The next important event in electrophonic and acoustic science was the publication by Helmholtz of his investigations in sound, and of König in the same line of research, but classical as these publications will forever remain, they for a time retarded the progress of apparatus for practical use, for the reason that they discouraged inventors by the mechanical complications which they apparently ascribed as indispensable to articulate speech. In fact, the perusal of their work left a serious doubt in the mind of many a student whether there was not something in articulate speech and its audibility by the human ear beyond the grasp of the mechanical mind of man.

These doubts were still increased by the attempts of Faber to construct a talking machine, after the system of the human organs of speech, a mass of intricate mechanism, levers, bellows, and pulleys, which gave an unearthly rendition of many words and sentences.

But the Bell telephone came, and its greatness consisted not so much in the fact that it carried speech over hundreds of miles, but that it taught how simple a piece of apparatus could produce such perfect results, and that any diaphragm, however thick, could be made to set up audible articulate vibrations.

The effect of this lesson was immediate, for hardly had the new wonder become known when an astonishing chain of logic formed in the brain of a distant devotee to science.

On the 30th day of April, 1877, Mr. Charles Cros deposited with the secretary of the Academy of Sciences, in Paris, a sealed envelope, containing what in translation reads as follows :

"PROCESS OF RECORDING AND OF REPRODUCING AUDIBLE PHENOMENA.

" In general, my process consists in obtaining the tracing of the to-and-fro movements of a vibrating membrane, and the utilization of this tracing for reproducing the same to-and-fro movements, with their relative inherent durations and intensities in the same membrane, or in another adapted for furnishing the sounds and noises which result from this series of movements.

" We are therefore concerned with the transformation of an extremely delicate tracing, such as that obtained with a delicate stylus rubbing upon a surface blackened by a flame, to transform, I say, these tracings in relief or intaglio, in resisting material capable of guiding a moving body, which transmits these movements to the sonorous membrane.

" A light stylus is connected with the center of a vibrating membrane ; it terminates in a point (metallic wire, the barb of a feather, etc.), which bears upon a surface blackened by a flame. This surface is a part of a disk to which is given a double movement of rotation and rectilinear progression.

" If the membrane is at rest, the point will trace a simple spiral ; if the membrane vibrates, the traced spiral will be undulating, and these undulations represent exactly all the to-and-fro movements of the membrane, with their times and intensities."

Up to this point the apparatus as described would represent a modified Scott phonautograph, in which the cylinder is substituted by a flat disk. Mr. Cros then continues :

" By means of the photographic process which, in fact, is well known, this traced, transparent, undula-

tory spiral is converted into a line of similar dimensions in intaglio or in relief, in resisting material like tempered steel, for instance.

"This done, this resisting surface is, by means of a motor apparatus, made to turn and to progress rectilinearly with a velocity like that which was used in the registration.

"If the reproduced tracing is in intaglio, a metallic point (and if it is in relief, a notched finger), held by a spring, bears upon the tracing at one end and is connected at the other end with the center of the membrane adapted for sound reproduction. Under these conditions, this membrane is not any more acted upon by the vibrating air, but by the tracing controlling the pointed stylus by pulsations exactly like those to which the membrane was subjected in recording, both as to duration and intensity.

"The spiral trace represents the successive equal periods by its increasing and decreasing length. There is nothing inconvenient in this if only the outer portion of the rotating circle is used, and if the spirals are close together, except that the central part of the disk is lost.

"In all cases, however, a helical tracing upon a cylinder is much to be preferred, and I am actually engaged in finding a practical embodiment of this."

This paper was only read in open session at the Academy on December 3, 1877, and in the meantime Mr. T. A. Edison appeared with the phonograph.

From what we can learn by published reports, Mr. Edison, some time in the latter part of September in the same year, was at work on an automatic telephone, by which he intended to impress a telephone message upon a strip of tin-foil, and let the indentations thereby produced act upon a variable resistance, such as a lampblack button, and thereby transmit the message over the wire. While one day at work on this, so the report runs, he, perchance, slipped the previously indented slip under the recording stylus, which, as in the Scott phonautograph, was connected to the center of a diaphragm, and then and there occurred the first actual reproduction by mechanical means of words registered before.

The phonograph became then, at once, an accomplished fact, for to such an experienced inventor it must have taken but a moment to mentally cover the cylinder of a Scott phonautograph with tin-foil and to indent the same at right angles to the surface of the cylinder.

Everybody remembers the sensation which the invention produced, and the prognostications which were advanced for it by the scientific press showed that the principle of the apparatus was considered to contain the germ of an ultimate achievement of the most accurate results.

In this respect, as well as in others, there are striking resemblances in the history of the two inventions with which I am dealing.

In both, the original idea emanated from Frenchmen, and both described one process of transmitting and a different process of reproducing speech. In the Bourseuil telephone there was a contact transmitter and an electro-magnet receiver; in the Cros phonograph, a written record and an engraved reproducing groove.

In both inventions the first realization occurred in the United States, and was effected with apparatus representing only the reproducer of the original conception. In the speaking telephone, the reproducing electro-magnet of Bourseuil became also the transmitter of Bell; and in the phonograph, the reproducing groove and stylus of Cros became also the record of Edison. Both the Bell and Edison apparatus were accepted for a time as containing the best mechanical and philosophical principle for the highest attainable results. In both, the aim at the beginning was to produce loud sounds, and both eventually contented themselves with a much fainter voice, which then became more distinct in articulation. Finally, in both inventions, the original transmitter was subsequently resurrected, and found to contain a pointer toward a superior principle as a transmitter and recorder, and it only remains now to use a Scott phonautographic record direct for reproduction in order to complete a parallel with the fact that a contact transmitter can also be used as a telephonic reproducer.

In making these parallels, however, I am aware of the fact that Cros had a better idea of a talking machine than Bourseuil had of a speaking telephone.

The paper of Mr. Cros, which can be found on page 1082, vol. 85, of the *Comptes Rendus* of 1877, appears to have been consigned immediately to obscurity. When ten years later I filed my patent application for the gramophone, not even the examiners at the Patent Office knew anything of Mr. Cros, and when I mentioned his name in the first publication of the "gramophone," even those best informed on the subject were surprised. Nevertheless, I considered it a duty to my friends to make the following statement to the editors of the *Electrical World*, which they published simultaneously with the "gramophone," on November 12, 1887. I said:

"On August 30 of this year, which was three months after the filing of my application for a patent, while in the office of my counsel, Mr. Joseph Lyons, I happened to look through a German scientific book in his possession, and reading up about the phonograph, I came across a remark stating that on April 30, 1877, one Chas. Cros deposited at the French Academy of Science a sealed paper which, when opened and read at a subsequent session during that year, was found to contain a description of the author's idea that a photoengraved phonautographic record, either in relief or intaglio, might be utilized 'for reacting through a stylus on a diaphragm, and by this reaction ought to reproduce the original sound.'

"Surprised as I was at this discovery, I requested Mr. Lyons to find out through his friends in Paris whether and to what extent Mr. Cros had ever carried his idea into practice, and an answer has since come to the effect that Mr. Cros never put his idea into practical operation.

"Whether he was taken aback by the *eclat* which the phonograph produced soon afterward; whether he became discouraged at the practical difficulties, of which I have found many at the outset of all my experiments; or whether he did not appreciate the peculiar advantage of the phonautogramic method— all this does not appear from the meager accounts so far to hand.

"But although, viewed in the light of equity, he had virtually abandoned his invention at the time when I independently and without knowledge of his prior idea took up the same subject, the fact remains that to *Mr. Charles Cros belongs the honor of having first suggested the idea of, and feasible plan for, mechanically reproducing speech once uttered.*"

As this statement has never been challenged since it was first made, I presume that it is substantially correct.

If we should attempt to carry out strictly the ideas of Mr. Cros, we would find many obstacles to obtaining practical results; and while undoubtedly the correctness of the general principle could be proved, the effects would not be as good even as those obtained by the original phonograph. Even with the application of the various improvements which I originally introduced, the process requires great care, and while this would not have been an obstacle, on account of the great advances made in photo-engraving, I have now abandoned the original process altogether, and have substituted one of great rapidity and simplicity.

But to return to the phonograph; we find this apparatus remained in an unsatisfactory and unfinished condition for nearly nine years.

Among those who believed that ultimately the phonograph could be turned to practical account was the well known original patron of the speaking telephone, Mr. Gardiner G. Hubbard; and being also financially interested in it, he, in 1883 or thereabout, caused the Volta Laboratory Co., an association originally founded by Prof. Bell as a laboratory, from the funds of the Volta prize awarded to him by the French government, to provide ample funds for the purpose of making an extensive series of experiments with the phonograph.

Prominent among the scientists connected with the enterprise were Prof. Bell, Dr. Chichester A. Bell, and Mr. C. S. Tainter. After two years of ardent labors these gentlemen came to the conclusions:

First.—That the indenting process had to be abandoned and an engraving process be substituted—*i. e.*, instead of pushing the record surface down with the stylus, as in the original phonograph, it should rather be dug out or graven into.

Second.—That the best substance, answering also the various other requirements, was beeswax hardened by an admixture of paraffine or other similar waxy substances.

Third.—That loud speaking was impracticable, and that the ordinary conversational tone gave better results, although reducing the reproduction to the loudness merely of a good telephone message.

In Patent No 341.214, of May 4, 1886, issued to Dr. Chichester A. Bell and Mr. C. S. Tainter, the following claims, among others, were granted:

"The method of forming a record of sounds by impressing sonorous vibrations upon a style, and thereby *cutting* in a solid body the record corresponding in form to the sound waves, in contradistinction to the formation of sound records by indenting a foil with a vibratory style, etc.

"3. The vibratory *cutting* style of a sound recorder, substantially as described.

"7. A sound record consisting of a tablet, or other solid body, having its surface *cut or engraved* with narrow lines of irregular and varied form, corresponding to sound waves, substantially as described.

"9. The method of forming a sound or speech record, which consists in engraving or cutting the same in wax, or a wax-like composition, substantially as described."

As a final result of all their labors, there issued in the spring of 1887 the graphophone, the first really practical apparatus of the phonograph type, and which was exhibited to admiring crowds in Washington and elsewhere.

To those who have never heard this instrument, I will repeat what I wrote about its performance in November, 1887, namely, that it appears to be the best instrument to take down business letters or dictations of any kind, in which the recognition matters little, so long as the words can be made out; also, that the reproduced sound is as loud as that of a good telephone message, but that the distortion produced by the engraving is sufficient to make the voice unrecognizable save to a strained imagination added to a previous knowledge of the author of the voice. The record ground of this machine is a thin pasteboard cylinder covered with wax.

Soon after the graphophone became generally known, Mr. Edison, evidently encouraged by the results obtained in this instrument, took again to experimenting with the phonograph, and, after trying wax covered with tin-foil for indentation, he abandoned that mode of recording, and also settled upon a cylinder of wax and the graving-out process, thus confirming the correctness of Bell's and Tainter's conclusions, and the new Edison phonograph and the graphophone appear to be practically the same apparatus, differing only in form and motive power.

I now come to the subject of the evening, the gramophone.

In my telephonic studies, I had become familiar with all the causes influencing the transmission and reproduction of the voice, and what had at all times struck me as forcibly as anything in telephonic phenomena was the fact that the self-induction of long iron wires or of polarized electro-magnets acted so detrimentally upon the articulation. Electrical resistance alone would simply have weakened the sound, but self-induction meant retardation, and this distortion of the transmitted waves which varied in length and amplitude. To appreciate fully what an extremely small amount of energy ordinary speech possesses mechanically, let us consider a few well-known facts:

A puff of air not strong enough to extinguish a candle flame, when blown across an empty bottle or into a whistle will produce a sound which may be heard over a hundred feet away. The amount of electricity needed to operate audibly a magneto-telephone is said to be less than one-millionth part of the electricity of a standard Daniell cell.

In considering such and other facts, it became evident to me that if such delicate energy, subdivided into may be several hundred waves, should indent or engrave itself into a solid body, it needed but very slight mechanical resistance to modify considerably the character of the sound vibrations. For what self-induction is to the telephone circuit, the variable resistance which impressible material offers to indenta-

tion or engraving at various depths is to the phonograph record sheet. Neither is proportional in direct ratio to the expended energy, and must give cause, aside from a reduction in size of the sound characters, also to a distortion of the same.

Your own Prof. Houston, in his learned remarks in the *Journal of the Franklin Institute* of January, 1888, says:

"The difficulties just pointed out, it would seem, must exist in any instrument, however improved in its mechanical structure, if it make the record on the phonogram at right angles to the surface thereof. Of course, if a substance was discovered for such a surface that offered a resistance to indentation exactly proportional to the depth of such indentation, the difficulty would, to a great extent, be removed."

All the experiments which were made with the phonograph and the graphophone confirmed the correctness of all these assertions, for the louder it was necessary to speak when recording, the less distinct became the articulation of the reproduced sound.

A change for the better was, therefore, to be obtained:

First. By tracing the vibrations, as in the old phonautograph, parallel to the record sheet.

Second. By reducing the resistance offered by the record medium to as near to nothing as possible.

Both principles, although not emphasized, are contained in the Cros document; but for my part, I found that merely smoked surfaces were utterly impracticable, because, if sufficiently black for a photo-engraving, and with the extremely small sizes of waves obtained with records that are adaptable for the reproduction of good articulate speech, the record lines were ragged, and, under a magnifying glass, looked like a set of parallel saws whose teeth would form a grating sound, which nearly drowned the articulation.

I observed, however, in my experiments, that the grayish deposit of lamp black which is obtained from the center of a kerosene flame was more oily and gave a somewhat sharper line than the deep black deposit caused by smoking with the top of the flame, and this led me to the highly beneficial process of oiling the plate prior to smoking the same, either by applying printer's ink or artist's paint by means of a printer's roller or by brushing oil over it. The smoke would then amalgamate with the oil, and forms a *fatty ink* of a rather dry consistency, which when crossed by a stylus shows, even under a microscope, a sharply cut, transparent line.

I still employ this process for small test plates, and prepare them as follows: One part of paraffine oil is mixed with twenty parts of benzine or gasoline. This mixture is poured on and off a glass disk, when the benzine evaporates, leaving an extremely thin layer of oil. This is held over a smoky flame and moved to and fro until the surface looks *just* dry. The application of artist's paint with a roller prior to smoking is still better.

I also adopted for the gramophone a disk of glass as a support for the smoke deposit, traced the sound record from below so that the displaced lamp black should fall down, varnished it after the tracing was done, and used this disk as a negative without therefore needing a camera or photographic chemicals outside of the chrome gelatine or chrome albumen used in developing a raised picture. I would refer, for a detailed account, to the already mentioned issues of the *Electrical World* and the *Journal of the Franklin Institute.*

The lesson of simplicity which the telephone was continuously preaching caused me at an early day to look for a simpler plan to attain my purpose, and in the specification originally filed by me I said:

"This record (meaning the phonautogram) may then be engraved either mechanically, *chemically*, or photochemically." And although for a long time without much hope for success, the purely chemical process of direct etching haunted me continuously, and was repeatedly suggested by others.

But it was easier suggested than carried out, because under the principles of the gramophone the etching ground was to offer practically no resistance to the stylus, and to make one which had no resistance mechanically, but did resist the etching fluid after the tracing was done, was the problem to be solved.

You will readily see that if we can cover, for instance, a polished metal plate with a delicate etching ground, trace in this a phonautogram, and then immerse the plate in an etching fluid, the lines will be eaten in, and the result will be a groove of even depth, such as is required for reproduction; such a process, of course, would be much more direct and quicker than the photo-engraving method.

In nature provision seems to be made for all the wants of mankind, and confident in this belief, I kept on trying to find a trail which led to promising results, and I have the honor to-night, for the first time, to bring before you this latest achievement in the art of producing permanent sound records from which a reproduction can be obtained, if necessary, within fifteen or twenty minutes, and which can be accurately multiplied in any number, by the electrotype process. It may be termed, in short, *the art of etching the human voice.*

The etching ground which I use is also a fatty ink, and one of the best I have found thus far is made by digesting pure yellow beeswax in cold gasoline or benzine.

Benzine, in a cold state, will not dissolve all the elements of the wax, *but only a small part*, namely, that which combines with the yellow coloring principle, and the resultant and decanted extract is a clear solution of a golden hue, which gradually becomes bleached by exposure to light. The proportions which I use are one ounce of finely scraped wax to one pint of gasoline. The bottle containing the mixture must be repeatedly shaken, and after the white residue has settled, the clear fluid is decanted or drawn off by a siphon.

I then take a polished metal plate, generally zinc, and flow the fluid on and off, as if I would coat with collodion. The benzine will quickly evaporate, and there remains a very thin layer of wax, iridescent under reflected light, not solid as a coating produced by immersion in a melted mass, but spongy or porous, and extremely sensitive to the lightest touch.

Partly on account of the too great sensitiveness of a single film, and also as an additional protection against the action of the acids employed in the subsequent etching, I may apply a second coating of the solution,

and this double coat I find to answer all requirements.

The protection which this porous or spongy wax affords from the acid is mostly due to the fact that watery solutions assume the spherical state on the film, while at the lines where the wax is disturbed the acid enters freely, and attacks the metal below.

A difficulty which only a short time ago appeared insurmountable was the accumulation at the point of the stylus, while tracing the sound record, of filamentary particles of dust which exist in the wax solution, and which, being ever present in ordinary rooms, settle down and adhere to the film. These dust particles are so fine that they cannot, as a rule, be detected by the most searching inspection of the prepared plate; but they become very conspicuous and a very serious source of annoyance when a long record is being made.

It must be borne in mind that the contact which the tracing stylus makes with the record surface is obtained by the elastic pressure from a piece of hairspring backed by a narrow blade of writing paper, and which pressure amounts to about five grains. Therefore, as this stylus passes through the fatty ink or other ground, and traces the fine undulatory line, the dust particles, as well as small portions of the displaced ink or wax, adhere to and accumulate at the point of the stylus and are dragged along, and the record thereby becomes blurred and indistinct.

I have discovered an effective means for overcoming this difficulty, and it consists in applying to the record surface a fluid that slightly adheres to the etching ground, and keeps it wet while the record is being made. I have found commercial alcohol to be very effective for this purpose, and it is used by pouring it over the plate just before the sound record is made. The alcohol, of course, immediately commences to evaporate, but not rapidly enough to disappear entirely before the record is finished, and there is no difficulty in adding more alcohol while the plate revolves. Under this condition, the point of the stylus remains perfectly clean, and it seems as if the dust particles had not been present at all.

The theory by which I explain this result is that the alcohol, so to speak, lubricates both the surface and the stylus, and prevents the adhesion of the filaments to the latter. At any rate, the application is highly beneficial, and the resulting line is so sharp and fine that it has to be widened in the subsequent etching process, in order to permit the acid to bite at sufficient depth. It can also be proved that the resistance of the wax film is decreased by the presence of the alcohol, but when this has evaporated, the wax film appears to be in precisely the same condition as before, even showing again the iridescent colors which disappeared on the application of the alcohol.

The film of wax being so thin, it is almost transparent, and if the record was made on this it could barely be detected. As, however, it is sometimes desirable to examine the record prior to etching the same, I can smoke the etching ground slightly by holding it high above burning camphor, so as to prevent a heating and melting of the spongy wax, and the alcohol poured afterward over this smoked surface does not seem to wash off any of the soot particles.

We now come to the important process of etching the record. Etching is done on steel, copper, or brass with nitric acid, perchloride of iron, or with a mixture of muriatic acid and chlorate of potash known as Dutch mordant. In modern photo-engraving nearly all the etching is done on zinc by means of diluted nitric acid, and these materials are preferred on account of their being cheaper than any other, and zinc is a metal easily obtained with smooth and even facings. In etching, however, on zinc, it is necessary continually to brush away the hydrogen bubbles which form and adhere to the lines, and as the etching ground is usually of firm and solid material (like asphaltum, hard wax, pitch, or resin mixtures), no harm results from the brushing necessary in order to obtain sharp edges along the lines.

Desiring to avail myself of the advantages offered in zinc plates, I soon found that no etching fluid was known that would be to zinc what perchloride of iron was to copper—namely, etch cleanly and without the appearance of hydrogen bubbles. To apply the brushing to the delicate, spongy wax film I employed was out of the question, as the first touch would wipe away the whole ground, and to permit the formation of hydrogen bubbles without brushing them away meant uneven and ragged lines and a distorted record.

While studying this matter over it occurred to me to, so to speak, depolarize the zinc plate by adding to the acid bichromate of soda, which I thought might prove efficient, as it does in the galvanic battery, to prevent the appearance of the bubbles while etching the zinc. It took, however, a comparatively large quantity of the bichromate to answer my purpose; so much that I concluded that the mixture had all the conditions of a chromic acid, or at least of a mixture of chromic acid and nitrate of soda. When I thereupon substituted a solution of chromic acid pure and simple, I found this to be a most excellent etching fluid, and that is what I am now using—namely, a solution of one part by weight of dry chromic acid dissolved in three parts by weight of water. I use the commercial acid, such as can be obtained from Churchman & Co., of this city, at twenty-five cents a pound. Such a solution etches on zinc a sharp and clearly cut line, and no hydrogen appears during the etching.

The back of the zinc plate had previously been painted with protecting varnish or molten beeswax, and within from fifteen to twenty minutes from the time of immersion in the chromic acid solution, and without disturbing it, a cleanly cut groove of sufficient depth is obtained for reproduction. This groove may then be deepened in the ordinary way of rebiting by covering the facing of the plate with resin dust, heat the same, and then immerse in diluted nitric acid. Under these conditions the brush may be applied until the necessary depth is obtained, generally in about one to three minutes, according to the strength of the etching fluid. I have used stronger solutions of chromic acid with no ill effects and a more rapid etching, and there seems to be a wide margin on this point, provided the plate is watched during the etching process. The lines very gradually widen in the course of the etching, but the upper edges of the grooves remain perfectly parallel and sharply defined.

Before proceeding with a practical demonstration of

the whole process, I will now describe the most important apparatus of the gramophone, the recorder. The translation of the movements of the diaphragm into the same movements at right angles, and with the extreme smallness of the motion and the liability of distorting them, adding to them, or detracting from their value in translating them, requires greater care to guard against error than an uninitiated observer would suppose; and when we examine the complex and extremely delicate mechanism which nature has provided in the human ear for giving a correct translation of air vibrations into nervous vibrations, it behooves us to be careful in the application of every day mechanics. Free as the telephone is, comparatively, from mechanical incumbrances, it is deficient in articulation of the consonants, and with the simplicity of mounting as required in the phonograph and graphophone, these difficulties of recording proper do not exist, and are shifted to the other portions of their construction and manipulation. In having attempted, therefore, to do justice to all sources of error, I am not yet prepared to say that my present recording apparatus is constructed and adjusted to the greatest attainable
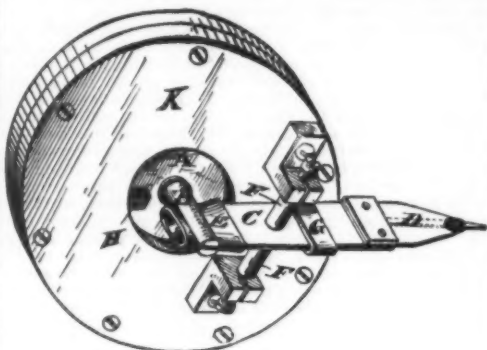

FIG. 1.

correctness. Those who are familiar with the tediousness of original research will admit that a new subject of this kind cannot be solved in its entirety within the space of a few months; and what I bring before you to-night, being the hasty results of machine finished but ten days ago, should be measured rather by the possibilities it opens than by the results so far attained, whatever merit you may accord to them.

My impression, however, is that there is very little of lost or added motion in my present apparatus, and whatever imperfections may exist must be looked for in the mode of reproducing the sound, rather than in the recorder (Fig. 1).

K is the diaphragm box; A is the center portion of the diaphragm; B is a brass post screwed to the diaphragm and slotted above: E is a piece of rubber tubing held in the slot and holding one end of the stylus, C. This stylus is made of stiff metal and is pivoted by the steel pivots, F F. D is a blade of writing paper reenforced by a piece of hairspring which extends, and forms the tracing point. G is a piece of rubber tubing around the stylus which dampens its musical vibrations; H is a piece of felt damper between the diaphragm and the diaphragm box, which acts as a general damping device.

The whole is mounted on a sliding carriage, which is drawn by clock-work across the disk, while the latter revolves at the rate of about thirty revolutions per minute.

DEMONSTRATION.

While the plate is being etched I will now let you listen to some phonautograms which I prepared in Washington within the last two weeks. The reproducing apparatus, or sounder, is constructed on precisely the same principles as the recorder, but of smaller dimensions and with more rigid mountings, so rigid, in fact, that if it was used as a recorder it would barely show undulations on a smoked surface when shouting into it.

The stylus is tipped with iridium like the points of a gold pen, the object of this being to prevent abrasion by the continuous friction with the hard record.

RECORDING DIAPHRAGM AND STYLUS.

In reproducing the sound I find that it is louder with hard contact substances, like metal, than with soft ones like rubber or plaster of Paris. Hard metals like copper, nickel, or brass sound louder than zinc or type metal, but the scraping sound, which is due to friction, is also increased unless the record surface is smooth and very highly polished.

But when an iridium-pointed stylus is rubbed over clean glass, a scraping sound is barely perceptible. I am now in communication with a firm that is making ornamental glass tiles by impressing upon red-hot glass plates fancy designs in relief or intaglio by strong pressure. You will readily see that if on the same plan we can impress a matrix showing the sound record in raised lines upon a glass plate, we would get a groove

in glass giving a loud reproduction with a minimum of disturbing sound due to friction.

In the description of November 12, 1887, I advanced the idea of mounting the sounder on a carriage and rails, and have the record groove itself be the screw which was to guide the point of the stylus across the disk from periphery to center. This has been improved upon by Mr. Werner Suess, the gentleman with me here to-night, and who is the mechanician of our little shop in Washington. He suggested to mount the sounder on a pivot at some distance from the disk and then let the reproducing groove guide the sounder across the disk over an arc of flat amplitude. This happy idea is embodied in the present apparatus, and is a very ingenious adaptation indeed.

REPRODUCTION.

It is, I trust, pardonable if I close by foreshadowing to a certain extent the practical applications of the gramophone.

A standard reproducing apparatus, simple in construction, and easily manipulated, will, at a moderate selling price, be placed on the market.

Those having one may then buy an assortment of phonautograms, to be increased occasionally, comprising recitations, songs, and instrumental solos or orchestral pieces of every variety.

In each city there will be at least one office having a
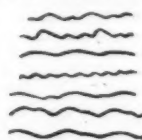

REPRODUCING APPARATUS.

gramophone recorder with all the necessary outfits. There will be an acoustic cabinet, or acousticon, containing a very large funnel, or other sound concentrator, the narrow end of which ends in a tube leading to the recording diaphragm. At the wide opening of the funnel will be placed a piano, and back of it a semicircular wall for reflecting the sound into the funnel. Persons desirous of having their voice "taken" will step before the funnel, and upon a given signal sing or speak, or they may perform upon an instrument. While they are waiting the plate will be developed, and, when it is satisfactory, it is turned over to the electrotyper, or to the glass moulder in charge, who will make as many copies as desired. The electrotype shells are mounted on thick pasteboard, and this is backed by a stiff piece of sheet metal. There is another process which may be employed. Supposing that his Holiness the Pope should desire to send broadcast a pontifical blessing to his millions of believers, he may speak into the recorder, and the plate then, after the words are etched, is turned over to a plate printer, who may, within a few hours, print thousands of phonautograms on translucent tracing paper. These printed phonautograms are then sent to the principal cities in the world, and upon arrival they are photo engraved by simply using them as photograph positives. The resultant engraved plate is then copied, *an infinitum*, by electrotyping or glass moulding, and sold to those having standard reproducers.

Prominent singers, speakers, or performers may derive an income from royalties on the sale of their phonautograms, and valuable plates may be printed and registered to protect against unauthorized publication.

Collections of phonautograms may become very valuable, and whole evenings will be spent at home going through a long list of interesting performances. Who will deny the beneficial influence which civilization will experience when the voices of dear relatives and friends long ago departed, the utterances of the great men and women who lived centuries before, the radiant songs of Patti, Campanini, Nieman, and others, the dramatic voices of Booth, Irving, and Bernhardt, and the humor of Whitcomb Riley can be heard and re heard in every well furnished parlor?

Future generations will be able to condense within the space of twenty minutes a tone picture of a single lifetime. Five minutes of the child's prattle, five of the boy's exultations, five of the man's reflections, and five of the feeble utterances from the death bed. Will it not be like holding communion even with immortality?

Postscript.—One of the peculiarities inherent with the gramophone is the possibility to enlarge the original sound by enlarging the printed vibratory characters of speech and then photo-engrave the same. In

RECORD LINES (magnified 6 diameters).

this manner it should be possible to get the reproduction at a much greater volume than the original sound. It would be interesting if some day speakers in a large hall would prefer to do their talking by machine, or to send speeches to a convention which they were unable to attend in person.—*Jour. Fr. Inst.*

QUILL toothpicks come from France, the largest factory, and which turns out about 20,000,000 annually, being near Paris. It was originally erected for the manufacture of quill pens, but when these were superseded by the steel implement the quills became toothpicks, to which use they had long been applied by the dreamy bookkeeper.

MICA MINING IN NORTH CAROLINA.

By WM. B. PHILLIPS.

MODERN mica mining began in North Carolina in 1868-69. Some little work was done in 1867, but beyond opening two or three pits, and getting out several hundred pounds of fine mica, not a great deal was accomplished. Reference has already been made in the pages of this journal * to the fact that some of the mines had been worked by the prehistoric inhabitants of the country, who disposed of the mica, in part at least, to the mound builders.† These "old men" were possessed of considerable skill, not only in the location of good deposits, but also in the extraction of the mica. The first is proved by the fact that by following their "leads" modern miners have found the best mica, and the second by the fact that sheets of mica of considerable size have been found in old mounds. Although some evidences of the use of other than stone tools have been found in the old drifts, the principal method used by these "ancients" was fire setting.

They did not penetrate into the hard rock to any great extent, nor is it likely that they sank shafts. Curiously enough, the method employed for opening the deposits in those days, viz., by open trench, is that at present used in New Hampshire. Shaft mining, vertical and underlie, is the exception in New Hampshire; it is the rule in North Carolina. In 1867, the Hon. Thomas L. Clingman, of Asheville, N. C., was induced by some New York mica dealers to undertake investigations in North Carolina for mica. Small sheets were then selling at $3 per pound, and the supply was uncertain. He began operations in Cleveland County, and found some good mica, which was shipped to New York. This was late in 1867 or early in 1868, and is the first instance I have been able to find of the prosecution of mica mining as a regular business, since the days of the Indian mound builders. Some work was done at this time in Burke and Rutherford counties, also, but with no very satisfactory results. He then transferred his explorations to Yancey and Mitchell counties, selecting as the best spots what was afterward the Ray mine, in Yancey, and the Silvers or Sink Hole and the Buchanan or Clarissa mines in Mitchell.

The first work done at the Silvers mine was not, however, in searching for mica, but for silver. It was known that at this place were great pits and trenches, amounting in all to some 1,800 feet in length, and in places 20 feet deep, with large trees grown up on the debris, and with every appearance of age. The very memory of these old miners had passed away, and nothing was left of them but their pits and trenches here and pieces of mica found in the Indian mounds in the Ohio valley. Tradition, always busy with the unknown, had determined that these workings had been undertaken for silver. Some specimens of the rock from the Silvers mine were pronounced by the ubiquitous practical miner to resemble some rich silver ores from Mexico, but the assay proved them to be worthless. The first work done at the Silvers mine was for silver, and it was not until it was found that there was no silver that attention was turned to the mica.

One at least of his New York friends had accompanied Clingman to Yancey County to search for mica, but did not think well enough of the enterprise to continue in it. Clingman, however, continued the work of mica mining at the Silvers mine, and obtained several hundred pounds of fine mica.‡ Being called away by more pressing business, he instructed his foreman to collect the mica and store it away. This, however, was not done, and several large blocks were left on the ground. A stock drover passing that way with his wagon took one of these blocks to Knoxville, Tenn. It was seen by J. G. Heap, of Heap & Clapp, dealers in stoves and tin ware, who at once recognized its value. He and his partner disposed of their business in Knoxville and went at once to Mitchell County, N. C., and began mica mining.§ This was in 1869. From that time and for several years they conducted a very profitable business, realizing for some of the mica, as Mr. Heap himself assured the writer, as much as $11 per pound.

Heap & Clapp first worked the Silvers mine, and by following the old leads obtained large quantities of excellent mica. They cut new trenches, ran an adit in and sank several shafts. They also worked the Buchanan or Clarissa mine, by shaft and adit, and found it equally good. Several other mines were opened and worked, as the Deake and Flat Rock. As local experience was acquired (the sine qua non in mica mining, as in every other kind), they extended their operations, so that up to 1882, of the 400,000 pounds obtained, Heap & Clapp must have mined by far the greater part. The average spot value of cut mica then was about $2 per pound, some, however, selling as high as $11. Even at $2 the total value of the mica up to 1882 would be $800,000. As to the profits, no very definite information can now be given. In 1880 the total real and personal capital invested in the North Carolina mica mines was $6,900, and the value of her product $61,675 ‖ —every dollar invested returned $8.93. I cannot say of my own knowledge whether these figures can be accepted or not. If true, they can be taken as fairly representing the capital and yield. They reveal a most remarkable state of affairs. The waste in mica alone, as we shall hereafter see, is from 85 per cent. to 95 per cent. in mica mining. That any mining operation utilizing at most only 15 per cent. of the stuff brought to bank should return $8.93 per $1 invested is simply incredible. It is stated ¶ that some of the free milling gold ores of Dakota are worked at a profit on $2 a ton, that some stream tin works in Cornwall yield only two pound of black tin per ton, ** and that the pay dirt at the Eureka claim, near San Juan, California, gave a profit on three cents per ton.†† So far as the refuse matter is concerned, these examples show there are places where it far exceeds the North Carolina mica mine waste. But it is not stated that there was anything like such a profit as is reported from the mica mines. It is so great as to be incredible. We shall

hereafter see that the New Hampshire mines in 1880 yielded twenty cents per $1 invested, which figure, while indeed somewhat low, is perhaps about right.

There has always been a curious reticence on the part of the North Carolina mica miners and dealers, and a corresponding difficulty in acquiring correct information. While indeed there are some notable exceptions (and to these I would return my warmest acknowledgments of their kindness), they serve but to make the background all the more obscure. I am often at a loss to know to what this reticence is to be ascribed. There are no more hospitable people in the world than the inhabitants of the mountains of Western North Carolina, nor any upon whose willingness to aid one in any laudable undertaking more assurance could be placed. And yet when it comes to mica mining they are reserved to the last degree, and it was only after repeated visits to the mines, and extended acquaintance among the miners, that I was able to acquire much information concerning the business.

It is proposed in the papers that follow to describe this business—the geology of the mining districts; the formation of the veins; dressing the mica; the percentage yield of cut mica from block mica, etc.

The success that attended the operations of Heap & Clapp in 1869 in Mitchell County soon induced others to enter the field. The profit was large, the work comparatively easy, and the mica abundant. The Indians (I use the term for lack of a better) had shown that good mica was to be had with very little expense or trouble. The whites were indeed for some time in doubt as to the purpose of the old works, but as on following the trenches and re-excavating the old diggings they found only mica, they soon came to understand this mystery. Had it not been for the prehistoric operations, much time and money would have been expended on searching for the true veins. But, as it was, the miners of 1869 took their cue from the miners of 1500-1600, and with their modern appliances—rude, indeed, it may be, but far superior to those of their predecessors—they carried on the business vigorously. It was not long before Mitchell and Yancey counties were dotted with prospect holes of more or less promise. The Ray mine, Westall, Joe Gibbs, Young, Baily Mountain, and others in Yancey County, the Pizzle (now Cloudland), Deake, Flat Rock, Mart Wiseman, (famous for rare minerals) and others in Mitchell County, were opened and worked. The fever spread, and in the counties of Buncombe, Haywood, Jackson, and Macon, other mines were added to those already in operation. Strange stories were told of the curious minerals found in some of the mines. J. G. Heap, the pioneer of regular mica mining, and one of the shrewdest of men, told me that he has seen masses of "uranium ore" as large as his head embedded in perfectly white kaolin. Not being then apprised of its value (in 1869 some parts of Mitchell County were on the confines of mineralogical knowledge), he paid no especial attention to it, and it was thrown on the dump and lost. He knew better before long, as did the others, and now uraninite and gummite, etc., are saved. A few years ago, watching the emptying of the water bucket at the Flat Rock mine, I was able to secure some very handsome specimens of uraninite and gummite. Several old miners standing near remarked that when the mine was first opened those minerals were much more common and in much larger pieces. The first miners mined for mica and paid but little attention to other minerals, and they very likely threw on the dump many interesting and valuable minerals as not being their point d'appui.

Mitchell County has been the scene of the most extensive operations, the deepest mines are located here, and by far the greater amount of mica sent to market from North Carolina has been obtained here.

The county lies between the Blue Ridge on the east and the Smoky Mountains on the west, being a part of the great western plateau between these two ranges. Its average elevation is not far from 3,500 feet, and it slopes gradually from east to west, the highest point, Roan Mountain, lying on the Tennessee boundary. The eastern boundary, the Blue Ridge, attains a height of 5,228 feet in the Sugar Mountain, while Roan Mountain on the west rises to a height of about 6,400 feet. There is on the whole, therefore, an upward slope toward the west. Some intermediate points, however, are much lower than the Blue Ridge. Thus, for instance, Bakersville, the county seat and the mining town for the district, is 2,550 feet, while the Watauga River, at the State line, is 2,131 feet. The most productive mines in Mitchell County lie within ten miles of Bakersville, on the east, northeast, south and southeast, at an elevation from 3,000 to 4,000 feet.

The geology of Mitchell County has been described as follows:

"Another considerable area of Laurentian rocks is found beyond the Blue Ridge,* occupying most of the mountain plateau between that and the Smoky Mountains, and in places constituting the materials of these chains. The rocks are foliated for the most part and consist of indefinite alternations of metamorphic strata, gneiss, hornblende, feldspathic and micaceous schists, and occasionally chloritic and talcose slates."

According to the same authority† the roughly shaped hills that occur through Mitchell County, scattered irregularly, and in close connection with the greatest dislocations of the strata, are to be referred to a very low horizon. He identified them as chrysolyte ledges (dunite). Though they occur very frequently in close association with the mica-bearing rocks proper, the connection between the two has not yet been made out. These chrysolyte or dunite ledges occupy the middle portion of the plateau, and are sometimes "nearly a mile long and several hundred yards wide."

It is still, I believe, an unsettled question whether this plateau is Laurentian or Lower Silurian, Cambrian. The absence of all traces of animal or vegetable remains (unless, indeed, graphite be considered vegetable remains), the well nigh exclusive occurrence of the older crystalline rocks, such as hornblendic and actinolytic rocks, schists, syenites, and more or less porphyroidal granites, and the extreme dislocation of all the members of the series, would seem to indicate an age beyond the Silurian. It would require patient and long continued observation, based chiefly on stratigraphical and petrographical relations, to settle this

* W. C. Kerr, Geol. of N. C., vol. i (1875), p. 128.
† Idem., p. 129.

obscure problem. It is known, however, that the mica-bearing rocks of the plateau between the Blue Ridge and the Smoky Mountains do not cross the Smoky Mountains, except sporadically, and then only for a short distance. On the western side of the Smoky Mountains, in Tennessee, we meet with the Silurian, but as it does not here carry mica, though only a few miles from the North Carolina mica zone, the assumption that the "mica zone" occurs in rocks older than the Silurian is somewhat strengthened, be that age Huronian or Laurentian.

Assuming, therefore, for the present that the mica occurs in the very oldest rocks, we may inquire as to its immediate congeners.

A mica vein is only a vein of very coarse granite, in which the feldspar, quartz, and mica have crystallized on a large scale. It differs from ordinary granite chiefly in this respect, that while in granite the crystallizing forces have, in a measure, interfered with each other, in a mica vein each has had, so to speak, free play. The difference between the two can best be conceived by imagining the ingredients of granite magnified several hundred, indeed several thousand times. The crystals of mica in granite seldom attain a greater size than one-sixteenth or one-fourth inch across; a single mica "block" from Mitchell County made two two-horse wagon loads, and could not have weighed less than 2,000 pounds! A single block of "A" mica from the Mart Wiseman mine in Mitchell County was 6 feet long and 3 feet wide. The crystals of feldspar in granite are seldom larger than one-sixteenth or one fourth inch across. A single feldspar *crystal* from the Balsam Gap mica mine, Buncombe County, weighs 800 pounds, and is now in the State museum at Raleigh. A piece of a feldspar crystal, now in the possession of the writer, obtained from the Deake mica mine, Mitchell County, weighs 30 pounds. It originally weighed 500 pounds, but was unfortunately broken by careless handling in the mine. Although no large quartz crystals have been obtained from these mines, large masses of crystallized quartz (generally the darker colored sorts) are constantly met with. The accompanying small red garnets are generally sprinkled through the quartz, and not through the mica or feldspar.

The origin of the mica veins will be discussed in the next article.

(To be continued.)

OUTINIAN SOCIETY.

THE society which took this uncouth name was founded in 1818 by Mr. John Penn, a descendant of William Penn, the Quaker founder of Pennsylvania. A design for a medal to commemorate this event was prepared, on the obverse of which was the representation of Penn holding the charter of Pennsylvania, and this inscription: "William Penn, deceased, 1718; Outinian Society founded 1818." On the reverse was a representation of Ulysses deriding Polyphemus, and from the name *Outis*, which Ulysses assumed in the Cyclops' cave, the title of the society was formed. As the ancient Greek traveler supported a good cause under that name, so the society undertook, whether for the repression of injustice or exercise of benevolence, to apply itself to remedy those evils which prompt the remark that the business of anybody is that of nobody. Thus neglected duties and neglected arguments were mainly attended to by the founders of the institution. The society owed its existence to a poem entitled "Marriage," published in the *New Monthly Magazine* in 1815, and republished in 1816, and was at first called the Matrimonial Society, but it soon changed its name to the Outinian Society. The objects of the society were to be obtained by the holding meetings of both sexes, at which critical and ethical lectures were delivered. The mode adopted to obtain these objects appears absurd enough, but the secretary put forward, as an excuse for the apparent trivialities of the scheme, the fact that Bishop Berkeley, who distinguished himself in the early part of his life by exact speculations, concluded his career of science by composing his *Siris*, in which the medical properties of tar water are extolled. In spite of the triviality, it is thought that some notice of a forgotten society that existed for seven or eight years may be of interest.

The Rev. D. Rivers read lectures at Saville House, Leicester Square, and afterward at Mr. Penn's house, 10 New Street, Spring Gardens, which was styled the Portico, because it was the only house in the street with a portico attached to it, and for several years the lectures delivered by different persons were continued every Saturday at this house during the London season. The tenth lecture was given on the occasion of the marriage of the Duke of Clarence (afterward William IV.) to the Princess Adelaide of Saxe-Meiningen, and the sixteenth lecture was delivered at Mr. Penn's country seat, Stoke Park. A missionary character was given to the association by the redelivery of the lectures in different parts of the country, such as Leamington, Cheltenham, Weymouth, Maidenhead, Uxbridge, Bath, Windsor, Southampton, and Lyndhurst. The reports of the meetings contained a statement of the number of visitors, by which it appears that the attendance was frequently very scanty; thus we learn that at Lyndhurst a torrent of rain fell at the time fixed for the meeting. The lecturer attended to fulfill his engagement, and the seventh lecture was read, but there were present to hear it only two ladies and three gentlemen, travelers staying at the "Crown" inn. On another occasion, at Weymouth, the rain was so violent as to prevent any of the inhabitants from leaving their houses to hear the lecture. Some of these Outinian lectures were published under the editorship of Mr. Penn, and in 1822 appeared two quarto volumes entitled "Records of the Origin and Proceedings of the Outinian Society," in which will be found engravings of some of the inventions noticed in this article.

One of the subjects treated of was the improvement of the drama, and the principles enunciated were exhibited in a tragedy by Mr. Penn, entitled "The Battle of Eddington," which was publicly produced. It was suggested to Chateaubriand that he should translate "The Battle of Eddington," for production on the French stage. Patriotic writers were to be rescued from dependence on the caprice of newspaper editors, and with this object, announcements which had been rejected by the editors were to be received and exhibited during the season at the Outinian lectures.

The president of the society was Mr. Penn, and sev-

* W. C. Kerr, vol. xxxi., No. 13, p. 211.
† Foster, Prehistoric Races of America, pp. 191 and 270.
‡ Thos. L. Clingman, priv. com., October 25, 1887.
§ C. H. Wiley, U. S. Treas. expert, Internal Commerce of the U. S., 1886, p. 255.
‖ Tenth U. S. Census, vol. xv., p. 843.
¶ Report of the Director of the Mint on Precious Metals, 1884, p. 251.
** Collins, Metal Mining, p. 56.
†† J. A. Phillips, Mining and Metallurgy of Gold and Silver, p. 160.

eral noblemen held the office of vice-president. The manager was Baron Nolcken; the treasurer, Roger Pettiward; the chaplain, the Rev. J. Masters; and the secretary and lecturer Jonathan, Richardson. The objects of the society were chiefly social, and improvements in the manners of good society were aimed at, many of which improvements have since been carried out. The reason for noticing the doings of this forgotten society in these pages will be found in the fact that the secretary occasionally gave an account of new inventions which he considered worthy of the support of the members. It is remarkable that several of these improvements, although pointed out more than half a century ago, have only just been adopted. For instance, Outinian lamp labels, for indicating the names of the streets at night, were actually set up in certain parts of the West End as far back as July, 1824. Labels were placed by the society at the corner of Cleveland Street and St. James Street, in Duke Street, York Street, King Street, and Charles Street, St. James's, and in Pall Mall East, and these were continued for some time, but the convenience does not appear to have been sufficiently appreciated to induce the parish authorities to enlarge the area of their use, or to renew those placed on the lamp posts when they were worn out. Besides those referred to, labels were placed in the two

his collar bone, and the *Morning Post* took advantage of the accident to draw attention to the Outinian safety saddle. A safety bridle was also produced.

A contrivance by which ivory balls were placed at the end of the ribs of umbrellas and parasols was invented by Mrs. Reid, of Charing Cross. The Outinian or town umbrella and parasol was thus supposed to be safer in the streets than those with the metal points projecting round the circumference of the silk, by which the eyes of the passers-by were endangered. Among the many ingenious contrivances brought forward were breakfast and dining room table waiters, bed pockets, and a covering for the shoulders of invalids sitting up in bed, to which the name omocalypse was given. Special attention was paid to contrivances likely to add to the comfort of travelers. Thus bands were placed in the traveling carriages to hold hats, such as are now common in railway carriages; and a strip of sealskin was placed along the top of the outer wooden blind, so that when the exterior of the carriage window became obscured by rain or other causes, the wooden blind could be let up and down and the glass cleaned by this means. The odoscope was a map or plan of a district, pasted on wood and varnished, on which pegs might be placed to mark the spots where the driver was to stop the vehicle. Another contriv-

A NEW JERSEY PINE FOREST.

A PURE forest of pitch pine (*Pinus rigida*) in Ocean County, New Jersey, is situated about twelve miles from the sea coast, and forms a part of the extensive and interesting domain which surrounds the Laurel House, at Lakewood, to the proprietors of which establishment it belongs.

This forest is interesting from several points of view. It is extremely picturesque and beautiful. It occupies ground which only fifty years ago was employed for farming purposes, and it is one of few forests composed of a single species of tree which can be seen in the Northern States, where a number of different trees are usually associated together in forest growth. The pines in this Lakewood forest have an average height of fifty feet, and their trunks an average diameter of ten inches. They stand so close together that grasses and undershrubs cannot survive in their dense unbroken shade. The forest floor is deeply carpeted with moss, however, and altogether this forest reminds one more of one of the planted pine forests of Northern Europe than anything we remember to have seen before in the United States. The rapid and vigorous growth of this young forest upon poor and comparatively worthless lands shows, moreover—and this is its

FROG HUNTING.—FROM A PAINTING BY H. BIEDERMANN-ARENDTS.—*Illustrirte Zeitung.*

short streets leading from Pall Mall to St. James's Square (John and George Streets), but these were removed by the parish officers on account of an act of Parliament passed to prevent illuminated letters becoming nuisances in those streets where there is a temptation to indicate coffee houses or similar places of meeting there situated.

In 1820, an early form of combined fire engine and fire escape, invented by Mr. Felton, of Birmingham, was exhibited and described to the Outinian Society, and figured in the records of their proceedings. The engine is placed below and a gallery above. Between the two is a ladder which could be used by the fireman when playing water on the fire, and also as a means of reaching the gallery when placed against the upper window of a burning house for the purpose of rescuing the inmates.

Another invention brought under the notice of the members was a safety saddle, attached to which in front were iron supports that touched the ground when the horse stumbled, and kept him from falling down. An objection was made to this contrivance that it had a very singular appearance when not required, but the inventor answered this by remarking that it would only be a nine days' wonder, and when in constant use no one would think it singular. An Archbishop of Dublin fell from his horse and fractured

ance was for the advantage of short persons in a crowd; it was a sort of stool which doubled up, and could be put in the pocket when not in use. It was styled an elevator.

It will be seen from this enumeration that the majority of the inventions brought under the notice of the society were connected with those minor comforts which were not likely to attract much attention except among the well-to-do and those who had but few serious evils to contend with. They carried out, however, the idea of the society contained in its name, that what is everybody's business is nobody's, and therefore suited to the consideration of those who were gathered together under the name of *Noman.* One of the proposals is of more national moment, and has some interest at the present time. It was a proposal for establishing a colonial emigrant institution and public drawing school, but what means were taken for carrying out the proposal do not appear.—*Jour. Soc. Arts.*

ACCORDING to MM. Errera, Maistrian, and Clautrian, alkaloids in the majority of cases occur in the interior of cells and not in the cell walls. They are to be regarded as waste products, but the plant is capable of again utilizing them in the formation of albuminoids.

chief interest—the way such lands along the Atlantic seaboard, north of Virginia, can be used to the best advantage. And finally, it illustrates the possibility of protecting, by means of a little trouble and foresight, such forests from burning up in the fires which annually rage, unchecked, over great tracts in the New Jersey coast region.

The pitch pine springs up spontaneously on the sandy soil which adjoins the coast from Massachusetts Bay to the capes of Virginia. Land which has once been tilled and then abandoned again to nature, in all this region is soon covered with a dense and almost impenetrable mass of young pitch pines, which, if fire is kept away from them, soon grow into a valuable forest. If the young pines do not appear spontaneously, the seed can be sown, at a very trifling expense, and with entire assurance of an abundant crop. The seed of no other pine, of no other tree, indeed, sown in the open ground, germinates with such certainty, as the farmers in some of the towns on Cape Cod have shown, and there is no other tree which can be grown so cheaply on these barren, sandy soils, or give better results in so short a time. And could the people of New Jersey be induced to follow the example of the owners of the Lakewood forests, and protect and encourage the young pines which are struggling to obtain possession of much of the lower part of the State, its wealth and

prosperity might be very considerably augmented. The pitch pine is not one of the most valuable pine trees of the United States. Its wood is coarse grained, full of resin, and not very strong. It is in every way inferior to the wood of the Southern long-leafed pine, which it resembles in structure and general appearance, but which it will never replace as long as the Southern pine forests continue to yield as freely as they do at present. But the time will come, perhaps, when New Jersey pitch pine will play an important role in supplying the people of the United States with timber. The Southern pine cannot last forever, under the existing management of these forests, and the species which is everywhere replacing it, the old field or loblolly pine (P. Tæda), is inferior to the Northern pitch pine in the quality of the timber it produces. Before Southern pine was brought to this market the pitch pine of New Jersey was the only available material in many parts of the State for timbers and flooring, and there are still houses in some counties where floors and floor timbers are known to have been in constant use for more than a century. But it is for firewood and for charcoal that the pitch pine is most valuable, and the nearness and accessibility of these New Jersey pine forests to great centers of population give them special importance as sources of fuel supply, which no other forests of this character in the country possess. Much land within three or four hours by rail of this city and of Philadelphia, now utterly unproductive and rapidly deteriorating through the fires which sweep over it every year, can be made highly productive and profitable by means of the pitch pine. People who own land of this character will see much to interest and instruct them in these Lakewood forests, and in those in the town of Orleans, on Cape Cod, in Massachusetts.—C. S. S., Garden and Forest.

AERATION OF WATER SUPPLIES BY NATURAL CANALS AND LOW DAMS.*

THE ideal drink of water is out of "the old oaken bucket that hung in the well." Remove the old bucket with its balance beam and substitute a modern pump, the ideal drink vanishes, the water seems insipid, the charm has left the well, we wish the old bucket back, lay it all to the new fangled notion of a pump; yet we stop there and fail to inquire the true cause. The charm lies neither in the old oaken bucket nor in the pump, but is due, pure and simple, to aeration. The bottom of the old bucket was about one inch above the chine of the staves. Every time the old bucket was sent down into the well it carried with it a quantity of air, measured by the area of bucket bottom multiplied by the depth that the bottom of bucket was inserted in the staves. The pump, owing to its mechanical construction, carried no air down into the well. Further comment seems unnecessary.

Again, on a larger scale: The mountain brook, rumbling along its rocky bottom, here a little cascade, there a pond, now coursing along a run of water-worn stones and bowlders, again a waterfall, and so on for perhaps miles, yet always pure, sparkling, and palatable to the tired fisherman! This is the ideal water supply—and why? Aeration and subsidence is the answer. What is aeration? Webster defines it, "to supply with common air."

Water is composed of oxygen and hydrogen, and is uniformly in the proportion of 100 parts of oxygen to 12½ of hydrogen by weight. Common air is formed of oxygen and nitrogen in the proportion of 77 parts of nitrogen and 23 parts of oxygen (Silliman) by weight.

Air is a mechanical mixture. The oxygen of the air is abstracted by all substances having an affinity for it, with the same ease as if nitrogen was not present. A chemical combination of oxygen and nitrogen forms nitric acid. The proportions then are four measures of nitrogen to ten measures of oxygen, while in common air the proportions are four measures of nitrogen to one of oxygen (Stockhardt).

This is a striking example of how wonderfully the properties of bodies change when they chemically combine with each other. When mechanically mixed together, the constituents of nitric acid form a life-sustaining gas, while when chemically combined they form one of the most corrosive fluids.

Oxygen has the greatest range of affinity of any known substance. Oxygen is absolutely necessary to all living creatures. Every combustion, however familiar to us, is a process of oxidation, in which the oxygen of the air combines with the particles of the burning material.

ORGANIC CREATION.

Oxygen, hydrogen, nitrogen, and carbon are the four elements which the Creator has established as the basis upon which the whole structure of organic creation rests; and from their combination with inorganic matter all the various forms of animals and vegetation proceed; yet the inorganic matter bears a very small proportion to the whole. Take an oak tree. Out of every 100 pounds only two to four pounds are inorganic, or ashes, and about the same proportion holds true of the animal kingdom. Oxygen seems to be the agent by which the changes in organic nature are brought about. There is no chemical change in organic nature without heat. Heat is the outward evidence of combustion, and, as combustion is a process of oxidation, it follows that the changes of organic nature are substantially produced by oxygen as the agent. All animate nature is constantly undergoing a change. There is no standstill. All animal and vegetable living matter of to-day will, in the course of a short time, be again resolved into the four elements, together with the different inorganic matters of which they are composed. And so the ceaseless change goes on, as it has gone on for centuries. Oxygen has been the principal active agent through all this, all tending to purity again. Were there not some such simple yet universal and powerful agent constantly at work, the earth would have been uninhabitable centuries ago, due to the fouling of the water supply, if from no other cause. Must it not then be true that water purification is due primarily to oxidation; and, if we try to imitate nature closely, will not our success be measured by the nearness with which we approach with our imitation? Is not nature's pro-

*A paper read before the New England Water Works Association at Providence, R. I., June 14, 1888, by Stephen E. Babcock, civil and hydraulic engineer; member of the New England Water Works Association; chief engineer Little Falls Water Works, Little Falls, N. Y.

cess of oxidation, by using the oxygen of the common air, the most available agent? Common air is the most abundant form of matter in and about the earth. Does not the oxygen of the air combine with the impurities, form new chemical combinations, the force of gravity precipitate them, and are they not thus removed and the foul water made wholesome? Is not this the true explanation of the purity and wholesomeness of the rock-bound mountain brook?

PROPORTION OF AIR WATER WILL ABSORB.

Regnault, the French chemist, gives the proportion of oxygen which water will absorb. He says:

"At the ordinary temperature water dissolves about 4⁄100 of its volume, or, in other words, one liter of water dissolves forty-six cubic centimeters of oxygen, or 100 cubic inches of water will dissolve 4·6 cubic inches of oxygen."

Wanklyn, the well-known English water analyst, also gives the possible proportion of air which water will take up. He says:

"Water is capable of absorbing, in a greater or less degree, every gas and every vapor which is placed in contact with it.

"All water which has been kept in open vessels is necessarily charged with oxygen and nitrogen gases, inasmuch as these gases form the chief constituents of the atmosphere; and if any sample of water be freely shaken up with large volumes of air, it will presently become charged with nitrogen and oxygen in certain well ascertained proportions, dependent on a physical law.

"A liter of water freely shaken up with large volumes of air at 15° Cent. will absorb 17·95 cubic centimeters of air, the composition of which is:

Nitrogen	65·1 volumes.
Oxygen	34·9 volumes.
	100·0

"The composition of the dissolved air is governed by the relative proportions of nitrogen and oxygen gases in the atmosphere, and by the coefficient of absorption of each gas at the temperature at which the absorption takes place. At 15° Cent. (according to Bunsen) the absorption coefficient of nitrogen is 0·0148, and that of oxygen 0·0299, while the relative volume of oxygen and nitrogen in air are:

Nitrogen	79 volumes.
Oxygen	21 volumes.
	100

"The relative proportions of nitrogen and oxygen, which water dissolves from the atmosphere at 15° Cent., are therefore, according to the law, 0·0148×79, 0·0299×71, which gives in percentages nitrogen, 65·1 volumes; oxygen, 34·9 volumes; total, 100.

"If water be taken from rivers and springs, and be bottled up without being freely exposed to the air, it will often be found to exhibit a very different ratio between the dissolved nitrogen and oxygen gases.

"Thus in the autumn of 1859, W. A. Miller found that a liter of Thames water at Woolwich contained 63·05 c. c. of dissolved gases, the composition of these gases being:

Carbonic acid	48·3 c. c.
Nitrogen	14·5 c. c.
Oxygen	0·25 c. c.
	63·05

showing extraordinary diminution of oxygen.

"Higher up the river the ratio of nitrogen to oxygen was quite different. Thus at Kingston, Miller found in a liter of Thames water, 52·7 c. c. of gases, consisting of:

Carbonic acid	30·3 c. c.
Nitrogen	15·0 c. c.
Oxygen	7·4 c. c.
	52·7

As will be observed, the ratio of the nitrogen to the oxygen in this water is very nearly that which they require in a perfectly aerated water.

"Undoubtedly the Thames water taken out of the river at Woolwich owes its deficiency of oxygen to the reducing action of urea and other matters poured into the river in the form of sewage."

SUBTERRANEAN WATERS.

Again I find that in a paper read before your association at Manchester, in June, 1887, Chas. Brush, C.E., of Hoboken, N. J., says:

"It is absolutely essential to good water that there shall exist in it a certain equilibrium of animal and vegetable life, in order to produce and regulate the quantity and quality of gases essential to maintaining it in good condition. Prominent among these gases is oxygen—not the oxygen of which the water is actually composed, but rather additional oxygen in solution in the water, which varies greatly under different conditions. With an excess of oxygen in solution, stagnant water is never found. Filtered waters or, what is practically the same thing, waters obtained from subterranean sources of supply, such as galleries or deep closed wells, after passing through natural filter beds, are generally bright, clear, and quite palatable. If allowed to stand any length of time, however, in an open reservoir, such water soon deteriorates."

The philosophy of this probably is that the absorption of oxygen from the air again causes new chemical changes to occur, the composition of the water is changed, and for the worse probably. If left a great length of time the new combination would throw down precipitates, and the water would be essentially changed in its chemical constituents.

Again Mr. Brush says:

"The best supply is always obtained from water in motion. All waters, and especially those obtained from the surface streams, are better at some seasons of the year than at other seasons, and these seasons differ with the different sources of supply. Generally, however, the worst season with any is either in midwinter or in midsummer. In the former case, when the streams are frozen over, the air is no longer in contact with the water, and consequently the water lacks life. In the heat of summer, especially after luxuriant vegetation,

the oxygen in solution in the water seems to be used up to a greater or less extent, and there is an excess of vegetable life. In both cases the result is a fishy taste and smell, and algæ likely to develop."

ROYAL COMMISSION ON OXIDATION.

The English royal commission on water supply (1869) in their report say:

"If the waters of the Thames had no impurities beyond the solid mineral contents, the question as to their wholesomeness and general suitability for the supply of the metropolis (London) would be easily disposed of.

"But attention has been called strongly to the organic impurities contained in Thames water, which, though more indistinct in their form and less appreciable in their quantity, are said to be more deleterious in their nature and to render the water, if not dangerous and unwholesome, at least liable to suspicion. The organic compounds dissolved in the water appear to be of very unstable constitution and to be very easily decomposed, the great agent in this decomposition being oxygen, and the process being considerably hastened by the motion of the water.

"Now as such waters contain naturally much air dissolved in them, the decomposing agent is ready at hand to exert its influence the moment the matter is received into the water, in addition to which the motion causes a further action by exposure to the atmosphere, and when (as in the Thames) the water falls frequently over weirs, passes through locks, etc., causing further agitation and aeration, the process must go on more speedily and more effectually. The effect of the action of oxygen on these organic matters, when complete, is to break them up, to destroy all their peculiar organic constitution, and to rearrange their elements into permanent inorganic forms, innocuous and free from deleterious quality."

ALUM.

Alum is the substance now almost universally used in the patent filters of the present day, yet an examination into its chemical constituents would seem to show that its efficiency is due to the large proportion of oxygen that goes to make it up. Its chemical symbol is $Al_2O_3, 3SO_3+KO, SO_3+24HO$, which, being reduced to its elements, indicates that 27·38 parts of the earthy metal aluminum, 64 parts of sulphur, 39·19 parts of potassium, 24 parts of hydrogen, and 320 parts of oxygen, make up the whole.

HUMBER ON OXIDATION.

Humber in his work on water supply says:

"Oxidation is another process carried on by nature for the purification of fouled water. It operates upon the class of impurities which, with one exception, are most to be feared, viz., organic matters liable to decomposition or already partially decomposed. The oxygen which is always dissolved in water exposed to the air, and the free atmospheric oxygen with which the organic matter is brought into contact by the motion of the water, combine with that organic matter, thereby converting it into harmless nitrates, nitrites, and carbonic acid. The more violent the agitation and more complete the aeration of the water, the more thoroughly will the organic matter be broken up and changed into these innocuous inorganic forms. The purifying agent is always at hand and in superabundance; it is only necessary to utilize it by bringing it into contact with the substances upon which it has to act."

The concurrent testimony of all who have looked up the question of water impurities and their removal seems to be that a violent mixing of common air with water is the most effectual and natural remedy.

AERATION AT LITTLE FALLS, N. Y.

At Little Falls, N. Y., where I am now engaged in constructing a water works system, the source of supply is an exceptionally pure mountain brook of three to four million gallons daily run. It is the finest trout brook in the whole section around Little Falls, yet, as I bring the water eight and three-quarters miles through an inclosed conduit, I concluded to try and imitate nature's process of improving it, and with what success the following description will enable you to judge:

The closed conduit terminates at a point about 2,500 feet from the distribution reservoir. From here to the distribution reservoir I constructed an open, paved channel to near the distribution reservoir. The object of this open channel is to aerate the water by causing the same to pass over a series of sixteen weirs, ten feet long, two feet high, distributed along the open channel at intervals of fifty and 100 feet apart, as the contour of ground admits. The paved channel begins at end of conduit, starting with a retaining wall, and is three feet wide on the bottom, five feet from top of bank down to grade, three feet nine inches of which is excavation in natural soil. The excavation is utilized to form tow path and berme banks, six feet wide, on each side of open channel throughout the whole length of the same, preventing any surface drainage from entering the canal. The open channel is carried 390 feet to a ravine or depression in surface of the ground; here a retaining wall is built up to top banks and two feet above the natural surface of the ground; the water is then carried in a pipe 160 feet through under the surface of the ravine. At the outlet another retaining wall is built up to top bank and two feet above the natural ground. Open channel starts again and is carried along for 580 feet to another ravine 100 feet long, where the water is again carried under through pipes and protected by vertical walls at each end, and with weirs or dams placed fifty and 100 feet apart, of the same size and dimensions as first stated. The water is again carried 700 feet in open channel to a point near the line of by-wash canal, which carries the water of the several streams formerly running through the reservoir basin, without entering the reservoir inclosure. From this point the water is conveyed in an iron pipe, 970 feet, to and through the bed of the distribution reservoir to a point out in the center of the same, distant about 480 feet from the gate house and 100 feet from the sides of reservoir; here the pipe is turned up vertically and held in place by a rectangular mound of masonry, which is carried up two feet above water surface of the reservoir. The water is allowed to fall over the sides of a square coping on top

of mound, giving a final oxidation to the water as it mingles with the waters of the reservoir.

The total oxidation of the water after it has been confined in eight and three-quarters miles of conduit is represented by the aeration over sixteen weirs or dams, ten feet wide, two feet high, a total length of open channel 1,600 feet, with a final overfall in the center of the reservoir, removing all possibility of fouling the water by surface wash on edge of reservoir. Again, by passing the water through pipes under the two ravines, all the surface water and drainage from the end of conduit to the diverting or by-wash canal is carried on the surface of the ground through these ravines, and cannot contaminate the water in open canal.

Near the point where the iron pipe from last section of aerating canal passes under the diverting or by-wash canal, I placed a branch with a pipe leading into by-wash canal, locating valves on two ends of the branch. The aerating canal forms also a series of subsiding ponds or reservoirs, and to provide for a ready means of cleaning them I placed the above mentioned branch controled with its valves. Whenever the canal ponds become filled with precipitated matters, the line leading to the distribution reservoir may be closed, the one leading to the by-wash canal opened; this allows all the water to waste into the by-wash canal. To clean the ponds and canal, it is only necessary to stir up the deposits with brooms or other suitable tools, and the water carries them along down and out through the by-wash canal to waste, until such time as the canal has been cleaned and water runs clear when by changing the valves the pure water may again be sent into the reservoir. The water is kept in a constant state of agitation with the air from the time it strikes the first dam to the end of the aerating canal. This I claim to be a fairly close imitation of nature's own way of rendering water pure and wholesome as well as pleasant and palatable.

MICRO-ORGANISMS.

Yet there is one item in water purification also to be looked into, the exception referred to by Humber. That it is a disputed point as yet as to how far aeration goes in removing the living germs seems to be the fact. Humber says:

"The class of impurities of which exception was made as being that most to be feared is, unfortunately, the class upon which the action of simple oxygen is of the most doubtful efficiency. The microscopic organisms known as germs would seem to defy the action of oxygen by that very element of vitality which renders them so persistently dangerous. While, however, the opinions of scientific men on this point are still so conflicting, it would be unwise here to do more than recommend the strictest caution."

COKE FILTER.

I determined to obviate this possible danger by adding a coke filter in the inlet chamber of the distribution reservoir. The particular description of inlet chamber and filter is as follows: The inlet chamber is of rubble masonry divided into three compartments. The first compartment nearest the water is arranged with two sets of screens running from top to bottom of house; three inlet tubes are placed on the inner side of this chamber, governed by regulating valves; these inlet tubes are placed at different elevations below the surface. Water may be drawn from either one as may be required. The water then passes into the middle chamber, which is a coke filter bed. The coke extends down from the top to a rack placed five feet above the bottom of the chamber. From this chamber the water is drawn into the third chamber by another inlet tube placed two feet above bottom and below the coke. From the third chamber two pipes lead the water down to the distribution system. A twelve inch mud pipe is also provided, laid through from the front chamber to the outer line of the embankment.

CLEANING FILTER.

Provision is made to clean the filter from time to time as may be required without interfering with the supply to the distribution, as follows: A short twelve-inch inlet cleaning tube is led from near the bottom of the outer chamber to a point directly under the center of base of the coke. A twelve-inch waste pipe connecting by branch with the mud pipe is let in from top of coke in middle chamber down to mud pipe in third chamber. Two additional supply pipes are carried through from chamber No. 1 to chamber No. 3, to use to supply the distribution while the coke is being cleaned.

When the filter is to be cleaned, the regular filter inlet tube is closed up. The additional supply pipe leading past filter is opened, supplying the distribution independently of filter bed. The short twelve-inch inlet cleaning tube is opened; the water then passes up through the coke, reversing the line of flow, thus freeing the coke from all the deposits, and the foul water is passed off through the twelve-inch waste pipe that leads from the top of the coke down to the mud pipe and thence out to the ground at the foot of slope of bank. The coke may thus be cleaned as often as it is found necessary. I adopted coke as a filter material from its very favorable action on the microscopic living germs.

Mr. Percy Frankland, the well known English analyst, has made some very exhaustive experiments to determine the relative values of coke, animal charcoal, and other substances. (Proceedings of Institute of Civil Engineers, England, 1886.) He says:

"Until the method of water examination by gelatine culture was devised, there were no available means by which the relative efficiency for the removal of micro-organisms of different filtering material would be estimated on a quantitative basis. The author has submitted to examination, as regards their efficiency in this respect, a number of filtering materials, employing in all cases equal thicknesses of the various substances which were also prepared in the same state of division. The results obtained in these experiments were:

"Ferruginous green sand. Initial efficiency organisms per cubic centimeter, before filtering, 80; after, none. Reduction per cent. 100. After thirteen days, before filtering, 8,000; after, 1,000. Reduction per cent. 88. After one month's action, before filtering, 1,280; after, 780. Reduction per cent. 39.

"Animal charcoal. Initial efficiency, organisms too

numerous to count before filtering; after, none. Reduction, 100 per cent. After thirteen days' action, before filtering, 2,800; after, none. Reduction per cent. 100. After one month's action, organisms before filtering, 1,280; after, 7,000. Reduction none, but an increase of 447 per cent.

"Coke. Initial efficiency, organisms per cubic centimeter before filtering, 3,000; after, none. Reduction per cent. 100. After five weeks' action, before filtering, 6,000; after, 90. Reduction per cent. 98½.

"The author has made further experiments on the efficiency of coke as a filtering material. In these experiments the filters employed were of similar construction, but an aqueous extract of garden soil was employed instead of urine water. Two similar filters (a) and (b) were submitted to examination under conditions as similar as possible.

INITIAL EFFICIENCY (SECOND DAY.)

Unfiltered water, 26,000 organisms per cubic centimeter.
     Filter (a)   none.
     Filter (b)   none.
Reduction in both, 100 per cent.
After three weeks' action, twenty-first day:
     Unfiltered water,   2,230 organisms.
     Filter (a)   339   "
     Filter (b)   219   "
Reduction (a) 85 per cent; (b) 90 per cent."

Mr. Frankland's experiments show that with the coke filter properly attended to, it may be relied upon to do the work expected.

CONCLUSION.

I am satisfied that this system of water purification by aeration, using water-ways or canals and a series of low dams, may be adapted to both gravity and pumping systems, and form a permanent, cheap, and reliable method of improving the quality of potable water, and when once constructed it runs itself.

EXPERIMENTS WITH SOAP BUBBLES.

THE paper in which Mr. C. V. Boys, A.R.S.M., demonstrator of physics at the Science Schools, South Kensington, described his experiments with soap bub-

SOAP BUBBLE EXPERIMENTS.

bles before the Physical Society, has been published in the *Philosophical Magazine*, and we make the following extracts: Every one is familiar with the fact that a soap bubble may be supported or even struck by a piece of baize or wool without coming into real contact with the material; it is also well known that two bubbles supported on the pipes from which they are blown, or on rings, may be pressed or knocked together with such violence as to materially alter their shape, and yet they do not come into real contact; there is a film of air between them which they are unable to squeeze out. This film, though thin to ordinary tests, is so thick that the colors of Newton's rings are only seen when one of the bubbles is very small, so that the air is squeezed out the more readily. If the pressure is increased so as to make a real contact, the bubbles both instantly burst. That this pressure may be made great before the true contact takes place will be shown in a variety of ways hereafter; but the following simple experiment makes it very evident that the air film will prevent the contact of two soap films that are pressed together.

Exp. 1.—Blow a bubble about 9 cm. (3·5 in.) in diameter, and place it on a ring with a diameter of about 7 cm. (2¾ in.) This bubble may be pulled or pushed through the ring by means of a smaller wire ring which serves as a handle. It may be so adjusted that the weight of the ring will not pull it through. Then a ring larger than the bubble, carrying a plane film, can be used to push it up and down through the ring, and yet the two films do not touch (Fig. 1).
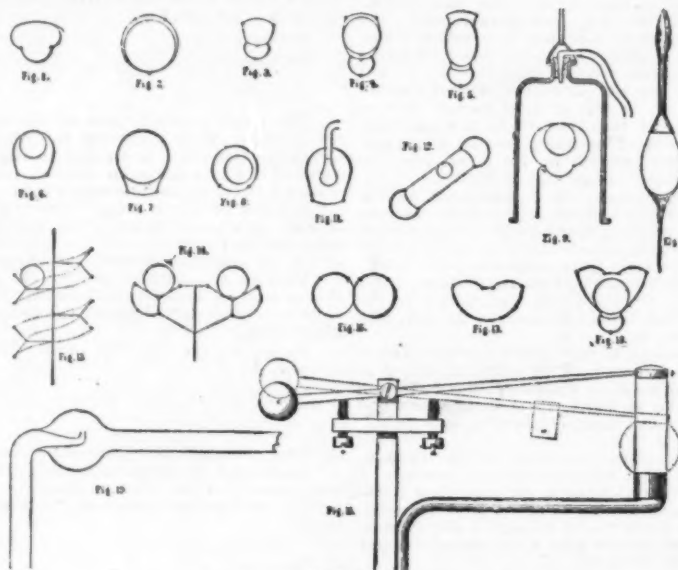
Exp. 2.—Blow a bubble on the lower side of the same ring that was used in Exp. 1, and if a large drop does not remain hanging to the bubble slowly apply solution to any part until as great a drop as can safely be carried has accumulated. Then pass the end of the pipe through the upper side of the bubble, and blow another inside, but take care in this case to have no excess of liquid. When the inner bubble is about twice as large as the outer one was at first, remove the pipe with a rapid movement. The inner one will now fall gently and rest within the outer one, the heavy drop pulling the thick part of the outer bubble out of reach of the inner one. The air of the outer bubble may then be withdrawn until the space between the highest point of the two bubbles is no more than two or three millimeters (Fig. 3).

The great pressure which the air film will carry is well shown by the next experiment, which, moreover, is more easily carried out than the last.

Exp. 3.—Proceed as in the last experiment, but instead of making a large drop on the first bubble, hang on a moistened ring of wire rather smaller than the fixed ring. This ring should be weighted until it pulls the bubble so much out of shape that a tangent to the curve at the points where the film meets the hanging ring makes an angle of 20° or 30° with the plane of the ring (Fig. 3). A bubble may then be blown inside and allowed to drop, when it will be found to rest on the conical seat provided by the outer bubble, while the heavy drops of liquid are kept apart, and thus there is no fear of contact (Fig. 4). These drops may now be both removed with the end of the blowpipe; then, if the lower ring is pulled down slowly, it will be found that the inner bubble is being squeezed out of shape until it becomes a beautiful oval, while the outer bubble shows the effect of the pressure by a corresponding enlargement (Fig. 5). If the lower ring is pulled down still further, the outer bubble is simply pulled in half, and the inner one, often unbroken, gently floats away. This shows that contact was not made, as in that case both would be immediately broken. If, however, instead of pulling the ring too far, it is held in the position shown in Fig. 5, it will be found that it is possible to swing the pair of bubbles round and round, and yet in spite of this violent treatment the bubbles refuse to touch one another. Or, if the lower ring is cautiously inclined and pulled away, the outer bubble will peel off it and remain attached to the upper one only. The two bubbles will now be spherical again, but there will be no heavy drop as in Fig. 2. The air of the outer bubble may be withdrawn as before, until the two bubbles are barely separate.

This experiment, and many of those that follow, may be made more beautiful by using for the inner bubble a solution strongly colored by fluorescine, or still better by uranine (for the knowledge of which I am indebted to Mr. Madan); then, if sunlight, electric or magnesium light is thrown on to the bubbles, the inner one appears a brilliant green, while the outer one remains clear as before.

The power of the surface tension to do work is demonstrated by blowing a large bubble below the ring and hanging on the weighted ring. If now a very small ring, a centimeter or more in diameter, is placed on that part of the bubble which is stretched across either ring, and then the part within the small ring is made to burst, the air will escape through the small hole, and the heavy ring will be lifted until it comes in contact with the upper one. If the film over the whole of the heavy ring is burst instead, the ring is pulled up so suddenly that it is difficult to follow it with the eye, and it strikes the upper ring with such violence that the noise is loud enough to be heard across a large room.

A suspended ring affords a simple and accurate means of measuring the surface tension of the soap film. A plane film is formed across a fixed horizontal ring and a light smaller ring is attached to the plane film, which is then broken within the smaller ring so as to leave an annular film only. Weights are then hung on to the suspended ring until the angle between the film and the plane of this ring approaches 90°. At this point equilibrium becomes unstable, and the lower ring falls away, but now both rings will be found to carry plane films, though the moment before neither did. On repeating the experiment a few times it will often be found possible to use such a weight that the ring will hang for some time, but will gradually sink, while the angle referred to above will approach more and more nearly to 90° as the surface tension of the film diminishes; and thus the exact surface tension at the particular moment of separation may be found by dividing weight of the ring and attached moisture by twice its circumference.

Exp. 4—Bubbles blown with coal gas are lighter than air, and rise. If, therefore, an inner bubble is blown with such a mixture of air and gas as to rise, it will rest against the upper side of the outer bubble, where there are no heavy drops, but where the films are thinnest and clearest (Fig. 6). A pair of bubbles blown in this way will sometimes last an hour when exposed to the air of the room. The inner bubble may be gradually enlarged by blowing in gas until the outer one can barely withstand the pull. The forms assumed under these circumstances are extremely graceful, and their beauty is increased by the play of colors on the two bubbles which the multiple reflections seem to intensify. If, when the inner bubble is not too large, as in Fig. 6

a little gas is gently let into the outer bubble, it is possible to so adjust the mixture of gas and air that the inner will float either near the top or near the bottom of the outer bubble, or about the middle, as may be desired (Fig. 8). If under these conditions the bubbles are left undisturbed, the richer gas above the inner bubble will diffuse into the poorer and heavier gas below, and the bubble will slowly rise or fall, according to the relative quantities of gas and air. The diffusion through the film is well shown in the next experiment.

Exp. 5.—Blow a pair of bubbles, as shown in Fig. 6, but make the inner bubble only just light enough to rest against the top of the outer one. Lower a bell jar over all, and pass a stream of gas into the bell jar by means of a tube passing through the top. As the air is gradually driven down, the outer bubble begins to feel the want of buoyancy, and gradually settles down, as shown in Fig. 9. After a short time the effect of the diffusion through both bubbles tending to enrich the gas of the outer bubble is made evident by the gentle descent of the inner bubble.

Exp. 6.—Into a large inverted bell jar pour a small quantity of ether, or to fill the jar with the vapor quickly wet a piece of blotting paper with ether and stand it on edge in the jar. Remove the paper, then blow a bubble and drop it into the jar. The bubble will rest on the ether vapor as on carbonic anhydride, and while floating the most violent agitation of the colors of the film will be seen. The bubble does not remain floating long at the same level; it gradually sinks into denser and denser layers of vapor, until it reaches the bottom or breaks on the way.

Exp. 7.—At the end of a wide tube, which has been enlarged at the lower end, blow a large bubble and lower it gently into the vapor of ether, holding the finger at the mouth of the tube. After a few seconds, it will be found difficult to remove the bubble by means of the tube, because its weight may have become sufficient to tear it away when buoyed up by the air only. If it is removed successfully, it will hang like a heavy drop; then, on removing the finger, a light may be put to the issuing vapor, which will burn like a Bunsen burner. If, moreover, the bubble full of ether vapor is held in a brilliant light, the shadow will show the ether vapor oozing through the film and falling away in a heavy stream (Fig. 10).

Exp. 8.—Blow a bubble with oxygen gas in a jar partly filled with ether vapor; on taking the bubble out of the vapor and carrying it to a light it will explode with a loud report. Sufficient vapor will penetrate the bubble, even while it is being blown, to make the mixture violently explosive.

Exp. 9.—The weight of the air is well shown by blowing a bubble with gas on a ring and then trying to blow an air bubble within it (Fig. 11). The inner bubble is then pulled out in a pear shape, and very soon breaks away from the pipe on account of its great weight.

Exp. 10.—If Exp. 4 be repeated, but instead of a heavy fixed ring a light aluminum one be used to which is tied a long piece of thread which may have a sheet of paper at the end, then the whole combination will float and rise in the air, even though, as in Fig. 7, practically the whole of the buoyancy is due to the gas in the inner bubble. In this case the inner bubble is the bag of a balloon, the outer bubble is the netting, and the wire and the things carried by it are the car. In this case the power of the air film to resist contact of the two films is more evident than ever. If any of the former figures 6, 7, or 8 are carrying a wire ring and thread, as described, it is possible by a suitable pull at the thread to release the pair of bubbles, which float away, one inside the other, until the ceiling brings the experiment to a conclusion.

Exp. 11.—If the inner bubble of Fig. 6 is made smaller than the ring, then the corresponding experiment to that represented in Fig. 5 is shown in Fig. 12. The small sphere will always roll to the upper end of the outer bubble, which may be pulled out to the cylindrical form and be inclined either way. This modification of the other experiment was suggested by Mr. Newth, to whom I had shown the previous combinations.

Exp. 12.—An experiment which is easily performed shows in a striking way how the air film resists being broken. If a pair of bubbles are blown, as shown in Fig. 4, and the vibrating prongs of a large tuning fork are brought quite close to the line where one bubble rests upon the other, both films will take up the movement of the fork, and a point of light reflected by the two films is seen spread out into a pair of rings, so violent is the motion—yet the films do not touch. It is hardly possible to suppose that the two films remain as close together where the movement occurs as in other parts of the line of support; if they tend to separate they form an exception to the general rule that a vibrating body attracts an object in the immediate neighborhood. In this case the inner bubble is heavier than the air in the outer one, both because of the weight of the film and the compression of the air within due to its tension. But if the same experiment is tried when the inner bubble is lighter than the air in the outer one, as it may be by holding one of the prongs close to the highest point of the bubbles shown in Fig. 6, or when either bubble is heavier or lighter than the air, the same result will be found—the bubbles will refuse to touch one another.

Exp. 13.—A spherical bubble may be dropped into one of these troughs and rolled from end to end, it may be taken out of one trough and dropped into another, or the frame may be held with its axis vertical, when the bubble may be dropped into the triangular pit, where, however, it will not remain long.

Exp. 14.—If, instead of a single helix of wire, two helices are fixed to the same axis, but not quite symmetrically, so that in any part the wire of one helix is nearer that above it than the one below, two helical films will not be formed, but there will be a single one in an intermediate position, which will be joined to the two wire screws by a pair of conical screw surfaces, these forming with the true screw surface a screw-shaped trough down which bubbles may be rolled or up which they may be wound, as water is wound up by a screw pump (Fig. 13). Further, if a series of small bubbles are blown along the helical edge in which the three films meet at angles of 120°, a spiral staircase is made of soap film, down which a bubble will run one or two steps at a time, and from which it will escape uninjured when it reaches the bottom. Of course, bubbles lighter than air, in the same way, will rest against the lower sides of a trough, or roll up instead of down the screw surface.

Exp. 15.—One more experiment in which the rolling of bubbles is the chief feature is worth describing. Three rings of wire, seen in section in Fig. 14, are joined together by wires, shown dotted, and are carried by a central axis, which may be made to rotate. After this frame has been dipped in the solution of soap, and the three radial planes broken, it is found to carry a circular trough, into which a series of bubbles may be dropped, while at the same time the frame may be kept rotating, so that the bubbles are rolling round and round like marbles on the rim of a solitaire board. A corresponding frame might possibly be made of light wire, which after dipping would rest on the bubbles in the first frame, thus forming a working model of the ball bearing. I have not, however, succeeded.

Fig. 15 shows a convenient apparatus for producing, as often as may be desired, a cylindrical bubble of any degree of stability. The short tube, *a*, is in connection with a supply of oxygen which is employed to blow the spherical bubble shown by the dotted circle. According to the position of the screw, *d*, this bubble will be larger or smaller before it comes in contact with the ring, *b*, which is held down by the loose weight, *w*. The gas tap is then immediately turned off, and the ring, *b*, raised by the action of the weight, *c*, until the screw, *e*, brings the movement to a stop. Thus the length of the cylinder depends on the screw, *e*, while its volume is determined by the screw, *d*, and so whatever degree of stability is found suitable can be reproduced as often as may be required. The poles of the magnet should be placed at about the level of the line, *p p*.

There is one other property of a pair of soap films resting against one another, but not in contact, to which I have not referred. In a lecture at the Royal Institution a few years ago Lord Rayleigh showed that two water jets if perfectly clean will, if directed so as to meet one another at a small angle, be reflected again and fall as two separate jets, never really coming into contact at all. If the water is not perfectly clean, the experiment will not succeed. He showed that such a pair of mutually reflected jets form a very delicate electroscope, so that if a piece of excited sealing wax is held even at a considerable distance they instantly coalesce. As the two jets in his experiments and the two bubbles in those which I am about to describe are in each case kept apart by a thin film of air, I expected to find a pair of bubbles attached to two rings in the same way act as a delicate electroscope.

Exp. 16.—If a pair of bubbles are blown on rings, which must be insulated from one another, as shown in Fig. 16, and the cover of a small electrophorus is raised even at some yards distance, instantly the two bubbles coalesce, as seen in Fig. 17, but do not burst, as they have hitherto been found to do. Or if the two rings are connected with a key and a single bichromate cell so that when the key is not pressed the rings are connected together, but when depressed they form the terminals of the cell, then at the moment of making the contact the bubbles unite because the electrostatic attraction between surfaces so very close together is able to squeeze out the air, which mere pressure had hitherto failed to do.

Exp. 17.—Bearing in mind how exceedingly delicate this is as a test of difference of potential, the following experiment seems the more decisive. The cover of the electrophorus may be brought so close to the side of the bubbles, shown in Fig. 4, as to pull them completely out of shape, and yet the outer film so completely screens the inner from the electrical action, even though the inner one is to all appearance in contact with the outer one, that there is no difference of potential between them, and so the film of air is not destroyed. I do not know any experiment which so clearly shows as this that electrical force is confined to the absolute surface of a conductor, and is not felt at any depth within it, however small.

Exp. 18.—One more experiment, which is a combination of these two, is worth performing. If one of the bubbles of Fig. 16 is replaced by the combination shown in Fig. 4 while the other remains as before, and if the cover of the electrophorus is raised anywhere in the neighborhood, immediately the two outer films join and become one, while the inner bubble, undamaged, and the heavy ring slide down to the bottom of the now enlarged single bubble, and give rise to the form shown in Fig. 18.

I am perfectly sensible of the fact that these experiments lie very closely on that ill-defined border line which separates scientific work from scientific play, but I trust that the beautiful way in which they illustrate the action of certain forces may be sufficient excuse for my showing members of the Physical Society what cannot fail to remind some of them of their nursery days.

The following particulars may be of service to those who wish to repeat any of these experiments.

The solution that I have used is composed of 1 part by weight oleate of soda and 40 parts of distilled water. These, when solution is complete, are well mixed with one-third the volume of glycerine and left for a week to settle in stoppered bottles. The liquid is then siphoned off from the impurities which have risen to the surface, and clarified with a few drops of ammonia. The thick wire rings and frames are made of tinned iron wire 1½ millim. (No. 17 B. W. G.) in diameter, well cleaned with emery cloth. The thin wire rings may be made of any thin wire, but aluminum about ½ millim. (No. 25 B. W. G.) in diameter does well. I have found it necessary to make a blow pipe with a trap, as shown in Fig. 19, to catch condensed moisture, which is apt to cause a failure if it mixes with the bubble. The diameter of the mouth is 7 millim. (0·28 in.) For detaching small light bubbles, a pipe with a smaller mouth should be used. When both gas and air are used in any experiment, and it is necessary to regulate the proportions very carefully, it is well to have a T-piece attached to the blow pipe, so that either gas or air may be blown or stopped at pleasure.—*English Mechanic.*

PROFESSOR WROBLEWSKI.

We regret that we have to record the death of Dr. Sigmund Wroblewski, the Professor of Experimental Physics at the University of Cracow. While working in his laboratory, the late professor was severely burnt through the accidental upsetting of a petroleum lamp, and unfortunately the wounds which he then received have been the cause of his lamented decease. Dr. Wroblewski was bo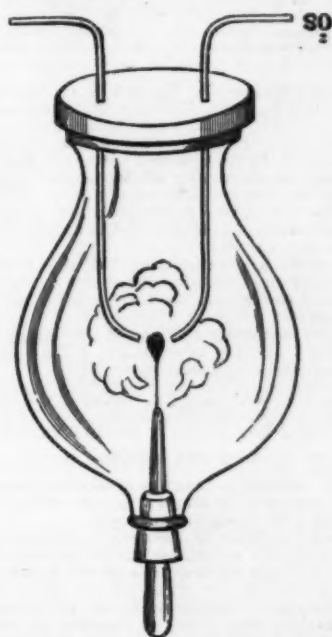rn in the year 1848, and studied first in the University of St. Petersburg, and subsequently continued his investigations at Strassburg. In 1882 he was appointed to the chair of experimental physics in the University of Cracow, and has, since then, contributed considerably to our knowledge of the subject of the liquefaction of the permanent gases and the behavior of substances under high pressures and low temperatures. The valuable supplement to the work of Cailletet and Pictet, which is due to the labors of Professor Wroblewski, cannot be easily estimated, and we deplore the occurrence of the fatal accident which robs the scientific world of such an able experimentalist in this important department of chemistry.

By his earlier experiments on the liquefaction of the permanent gases he was able to determine the critical temperatures and pressures of oxygen and nitrogen, and also from his researches on the absorption of gases by liquids under high pressures proved that carbonic acid did not form the hydrate $CO_2.H_2O$. In conjunction with Dr. K. Olszewski, he extended his investigations to a study of the behavior of carbon bisulphide and alcohol at low temperatures, and succeeded in solidifying both these liquids. Nitrogen and carbon monoxide were liquefied under conditions similar to those employed in the case of oxygen, but liquefaction was attended with greater difficulty. By the rapid ebullition of liquid oxygen a temperature of about --186° was obtained, and at this temperature the sudden expansion of compressed nitrogen caused it to form snow-like crystals, and hydrogen, at the same temperature, under a pressure of more than 100 atmospheres, was also obtained in the liquid condition. The low temperatures observed when these gases boil were registered by the aid of a galvanometer and a thermo-electric couple, and by their use he determined the boiling points of the liquid nitrogen and hydrogen under known pressures. The insulating properties of liquid oxygen and nitrogen were recorded in a paper communicated to the *Comptes Rendus* in 1885, and in the following year he succeeded in determining the density and properties of liquefied air, and established the fact that atmospheric air, when in the liquid state, behaves as a mixture. The atomic volumes and the densities of these gases were also first accurately determined by Professor Wroblewski, and his results have since been confirmed by more recent observers. The theoretical questions which arise out of researches of this nature also claimed his attention, and in a long paper published last year in the *Annales Phys. Chem.* he proposed that the relation of the physical properties of gases and liquids should in future be represented by curves showing the rate of change of pressure with temperature for different densities instead of by isothermal lines. These curves he called "isopyknics," and from inspection of the diagram of such "isopyknics" new and important conclusions were deduced. In diagrams of this nature the expansion of the substance by heat, and its compressibility, are expressed by the passage from one isopyknik to another either in a vertical or horizontal direction. This method of representing the phenomena accompanying the change of state of substances must therefore also be associated with the important experimental work by which the name of Wroblewski will be remembered.—*Chem. News.*

A NEW LECTURE APPARATUS FOR MAKING SULPHURIC ANHYDRIDE.

By Dr. W. R. HODGKINSON and F. K. LOWNDES, F.C.S.

We have lately designed a piece of apparatus which exhibits in a most striking manner the oxidation of

SO_3, by means of oxygen in presence of spongy platinum, and which we think will be of interest and use to other lecturers. It consists, as the sketch will show, of an inverted bell jar having an aperture at each end; through the lower one is pushed a caoutchouc stopper having passed through its center a small rod of wood, attached to the upper end of which is a piece of moderately thick platinum wire, holding in its position in the center of the jar a block of spongy platinum. The upper aperture of the bell jar is closed with a well-fitting but not fixed piece of wood, through which are pushed two glass tubes bent at right angles outside, and inside curved so as to impinge on to the platinum, as shown. The block of sponge is raised to a moderately high temperature in a Bunsen flame, and pushed into its place; streams of oxygen (or even air) and sulphur dioxide are then passed through their respective tubes; instantly the globe becomes filled with vapor of sul-

phur trioxide, and if the supply of gases is steady, and not too violent, a large quantity of this substance can be made in a very short space of time. The experiment is still more striking if the SO_2 be passed for a short time before starting the oxygen, or *vice versa.*—*Chem. News.*
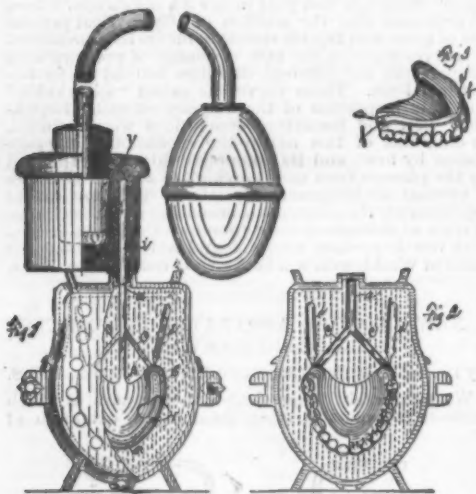
ALUMINUM BASES.

DR. C. C. CARROLL'S clinics—aluminum cast dentures—are interesting those who desire to discard the vegetable bases. He has succeeded in overcoming the difficulties encountered by those who have for years been endeavoring to make use of aluminum. By the use of the pneumatic crucible he is able to make the cast, and by making an alloy of aluminum with platinum, silver, and copper, he reduced the shrinkage from $\frac{1}{11}$ to $\frac{1}{116}$ of an inch, practically *nil.* The percentage of alloy is $3\frac{1}{2}$. Take an impression for this aluminum cast work as for any other work; then from this impression make a model of plaster of Paris three parts, and of fine sand and marble dust, one part. Proceed very much as in rubber work. For model base plates take common paraffine wax and roll it down to about twenty-three standard gold plate gauge.

There are various forms of mounting the common rubber teeth for use in this aluminum cast work, the simplest of which is to cast a base plate with a flange or under-cut for the purpose of attaching the teeth by pink rubber or celluloid. Upon this cast base plate place wax and get the bite, which place upon the articulator and mount in the usual manner for rubber work. Then attach the teeth to this aluminum base plate, making an artificial gum of pink rubber or celluloid.

Another form of mounting is to place plain teeth directly upon the temporary wax base plate, the same as in mounting for rubber work, with the exception to space the teeth slightly to allow for slight contraction. Along the labial border make an under-cut in the wax base plate, which under-cut is reproduced in the aluminum plate permanently when cast, for the attachment of a gum-colored facing of pink rubber or celluloid.

The accompanying cuts give a very good idea of the mode of investing, and full and explicit directions are furnished with each outfit. If these are carefully fol-

lowed, success will result. Those who are familiar with cast bases will have no difficulty manipulating aluminum.

Fig. 1 shows the temporary base plate on the model, and invested in the flask, with a section of flask and investing material cut away. *a b* is the middle gate; *c c*, gates from the heel to the middle gate; *d d*, perpendicular gate; *e f*, the flange on base plate; *h*, base plate cut through to show position on the model; *v v*, direction of metal in casting.

Fig. 2 shows a denture mounted and invested in female part of flask for base No. 2, one half, with the wax removed, or for base No. 1, when to be cast directly on the teeth.

Fig. 3, *ff*, represents the line of the flange after attachment with rubber or celluloid; *a a*, alveolar edge of plate.—*Archives of Dentistry.*

THE NEW SUGAR SUBSTITUTE.

By JOHN MICHELS.

WE have received a quantity of saccharine, and have now been testing it for about a month, using it in the place of sugar for domestic purposes.

We found it difficult to dissolve even in boiling water, although soda was added, and other means taken according to formula for making a perfect solution. This trouble has been spoken of by all who have made use of this substance. Saccharine is not altogether odorless or tasteless, but in use it imparts no particular flavor, and we found its sweetening property all that could be desired. We thought it convenient to make a solution of sufficient strength that a teaspoonful would sweeten a breakfast cup of tea. Using it in this manner tests were made in many ways, such as making lemonade, custards, puddings, mixing with acid fruits, and various kinds of domestic cooking. In all such cases it imparted an agreeable sweetness, but in our experience we found it did no more than counteract or neutralize acidity. Now, it is well known that sugar not only has a sweetening property, but seems to be possessed of a power of bringing out an increased flavor of the substance it sweetens; in other words, the flavor is intensified.

We found that the use of saccharine, on the contrary, appeared to deaden the flavor of the substance sweetened, which is a great disadvantage. Attention has also to be drawn to the fact that sugar is a food, a quality not possessed by saccharine, which passes through the human body unaltered and never di-

gested, affording no nutrition to those who eat it. For these reasons it can never take the place of sugar as an article of diet, however cheaply it may be produced. It, however, has its use, and will be a blessing to those persons afflicted with diabetes, a disease of the kidneys in which the use of sugar is prohibited by all medical authorities. As saccharine passes through the body undigested, it can be used by such persons with impunity, which will be a great boon to those having a sweet tooth.

We do not, however, recommend the unlimited use of saccharine, as we are not altogether sure of its inert property while passing through the human system. In some cases we found it caused irritation of the bowels of a slight degree, but not approaching inflammation, and we have thought that some persons may suffer by its use in this manner. After all, the use of sweet food is only an acquired taste, a mere habit, and we have found by a practical test that the palate soon becomes accustomed to unsweetened foods and that finally they are preferred. We therefore would advise those who are prohibited from eating sugar to use saccharine very sparingly, and only when necessary to counteract *great* acidity, such as is found in the lemon.

We trust the day is far distant when "saccharine" will be produced at a cheap rate, as it will in that case be largely used as an adulterant in the place of sugar. It will be very difficult for the public to distinguish the difference, but saccharine will at all times be readily traced by the chemist who is a competent analyst, as a formula is already known for its detection.—*Health.*